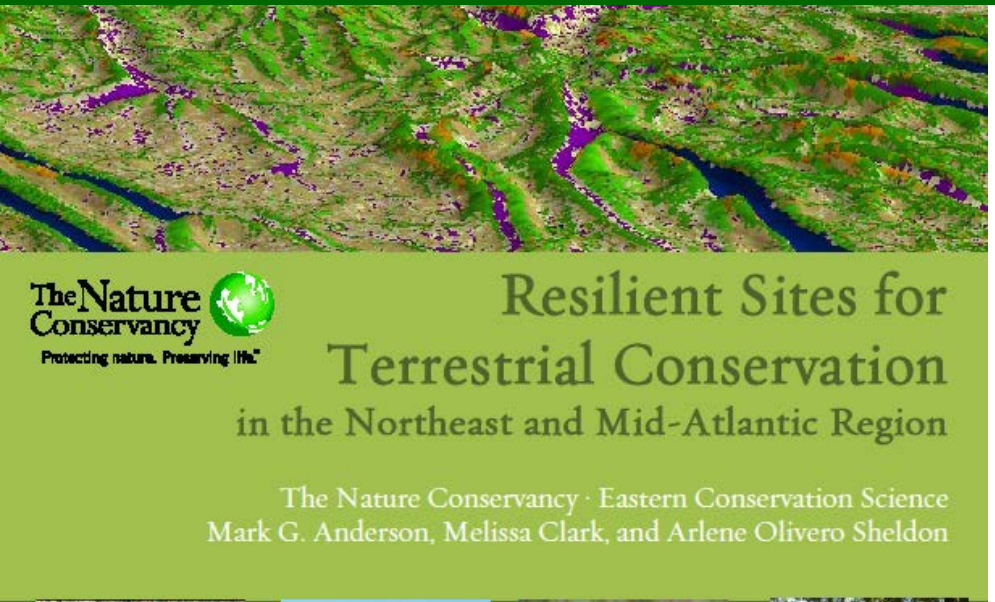
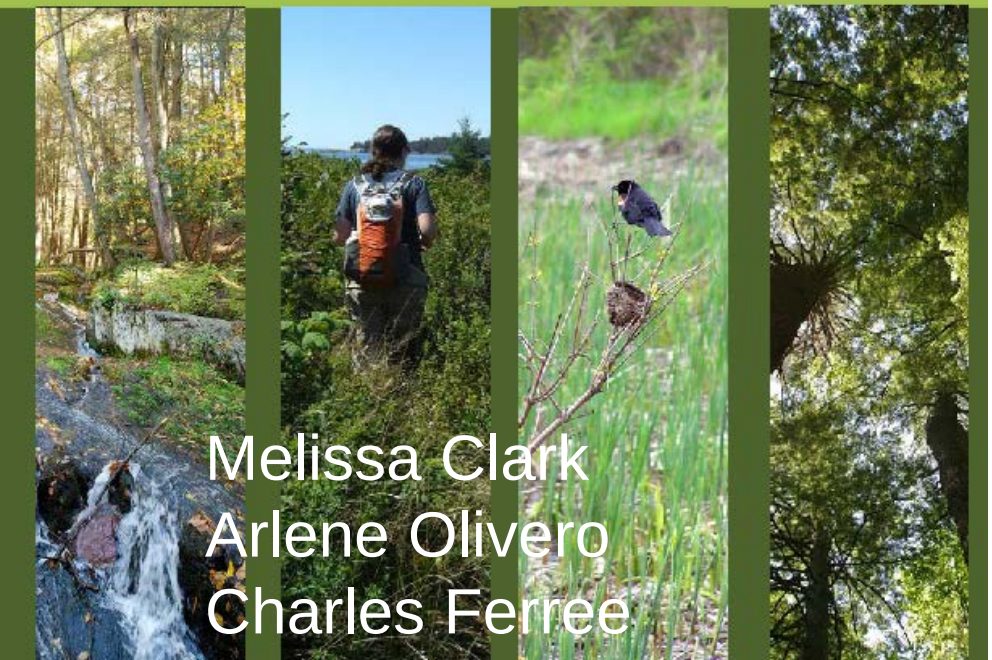
Identifying and Protecting Resilient Ecosystems:

New directions for conservation in a changing world

Mark Anderson, PhD.
Director of Conservation Science
Eastern North America Division

Acknowledgements





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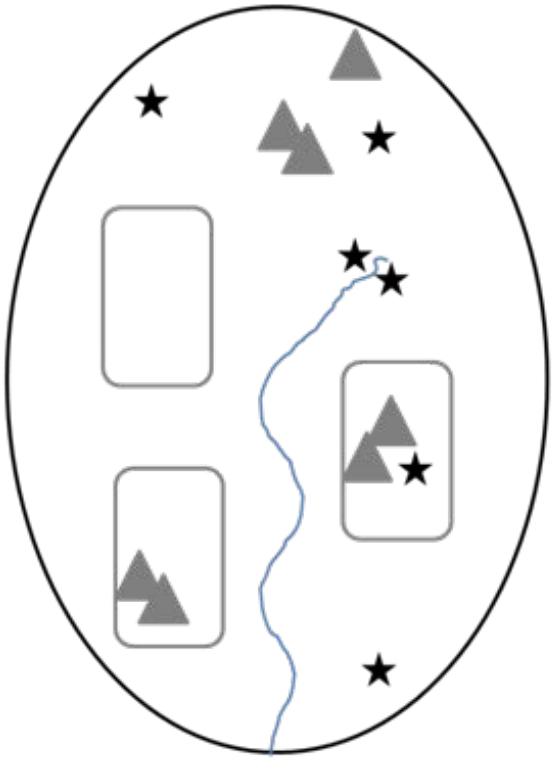
  - Doris Duke Foundation,
  - The Northeast Association of Fish and Wildlife Agencies
  - The Nature Conservancy

http:conserveonline/ECS/resilientsites1

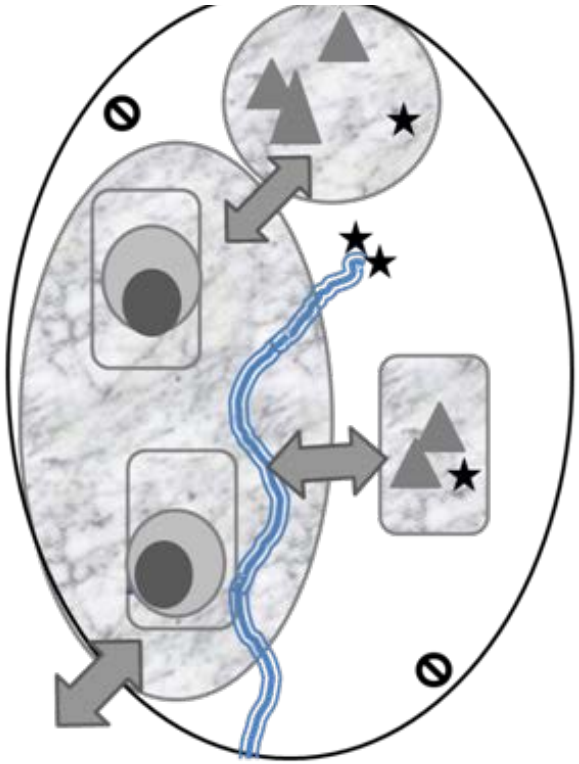
From Sites to Whole Systems

Sites

A Collection of Sites



A Network of Sites, Features and Processes



Habitat block

Community

Stream network

Rare species

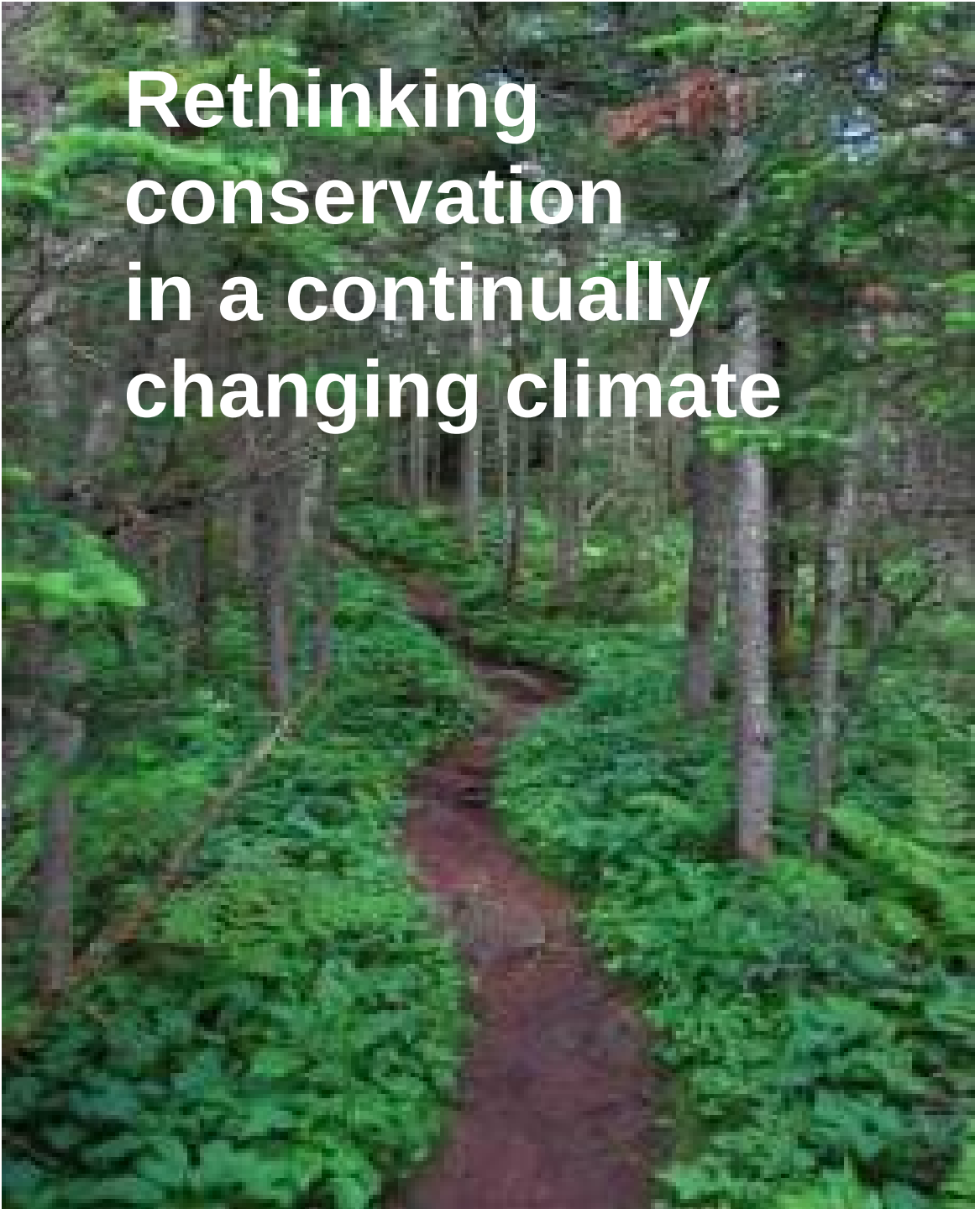
ARA

Matrix Lands

Linkage

High Quality Core/Buffer

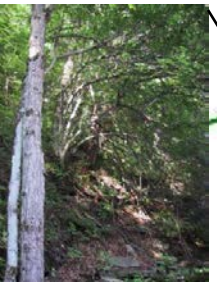
What does climate change mean for conservation?



- Focus on the Stage
- Identify and conserve natural strongholds
- Maintain a permeable landscape.

Geology and Diversity

Bicknell's thrush
High elevation
Granite & mafic



Shale barrens
Shale slopes

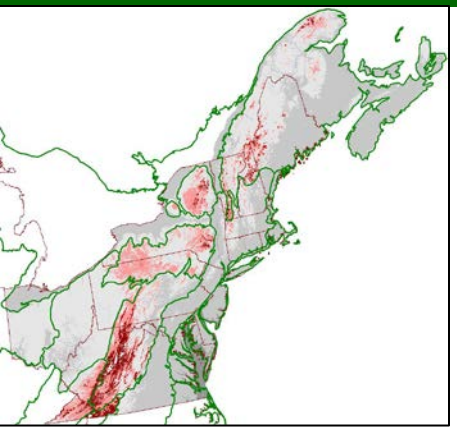
Serpentine Aster
Serpentine

Piping Plover
Sandy beaches

Alasmidonta Mussels
Limestone rivers

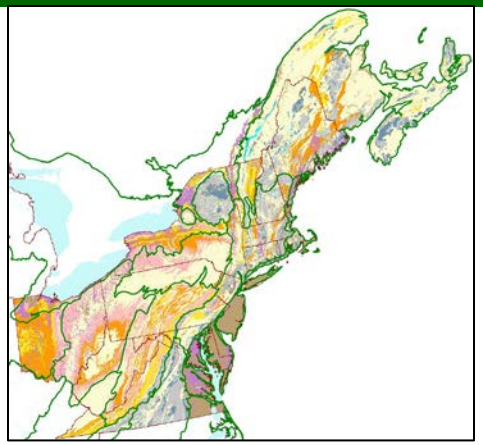
Spartina grass
Fine silts and muds

Physical and Climatic Factors (22)

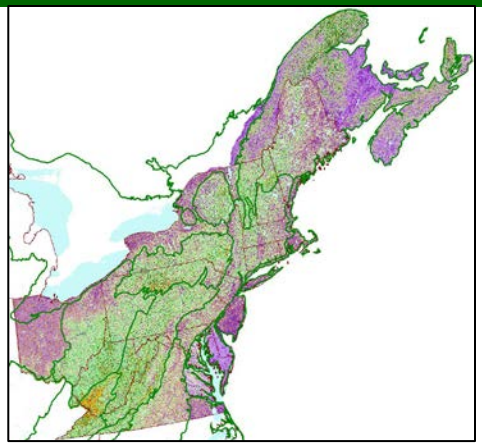


Elevation
Max
Min
Range

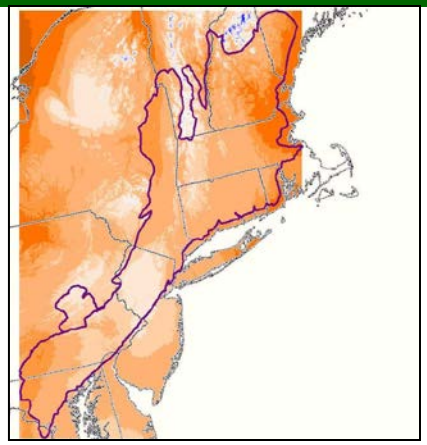
Area
Latitude



# of Geology classes
Amount of each:
Sedimentary
Shale
Calcareous
Mod Calc
Granite
Mafic
Ultramafic
Coarse sand
Fine silt



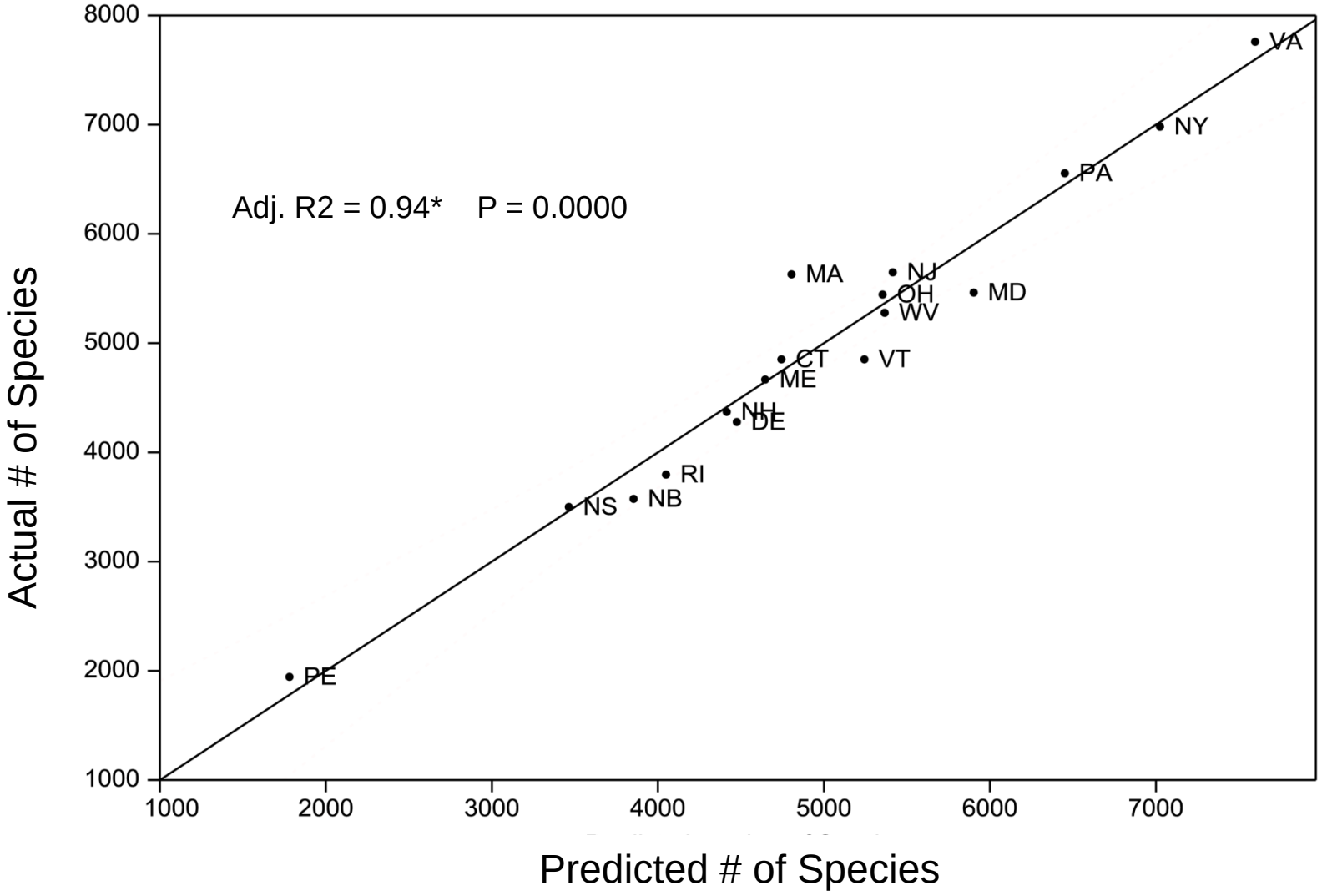
# of Landforms
Amount of each:
Cliff
Upper slope
Summit
Side slope
Cove
Valley
Wet flat
Dry flat



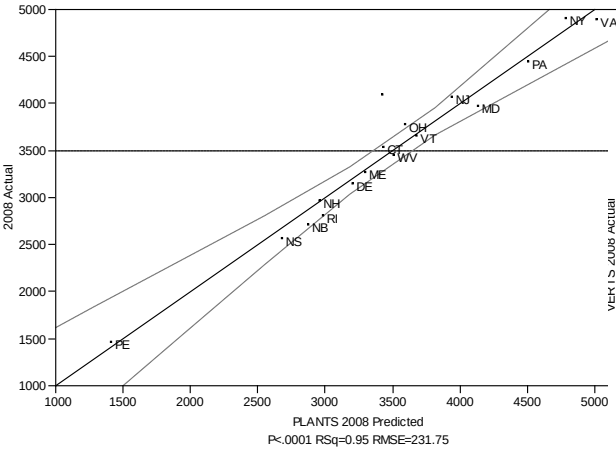
Mean diurnal temp. range,
Mean annual temp. range,
Mean annual temp.
Mean annual precip.
Precip. warmest quarter,
Min temp. coldest month,
Mean temp. coldest quarter.

Species Diversity

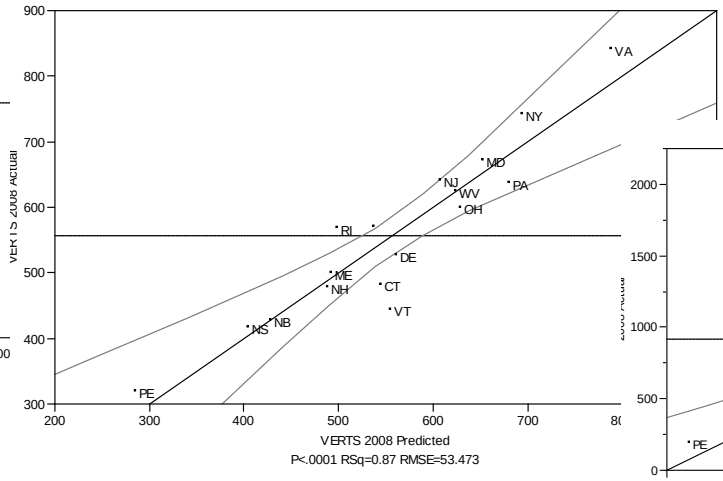
1) # of Geology classes, 2) Latitude, 3) Calcareous substrate, 4) Elevation range



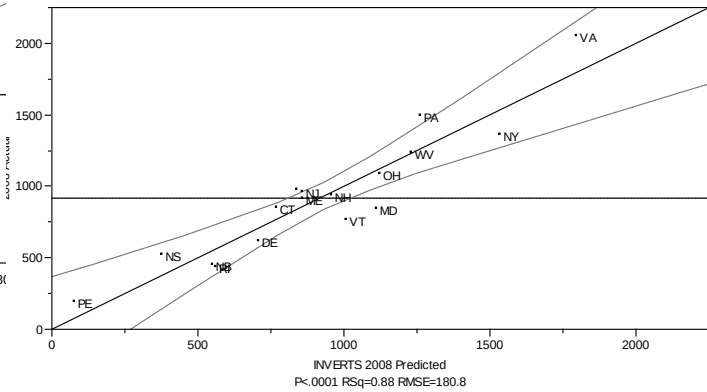
Anderson, M. and C. Ferree. 2010. Conserving the Stage: climate change and the geophysical underpinnings of species diversity. PLoS ONE .5(7) 36 p.



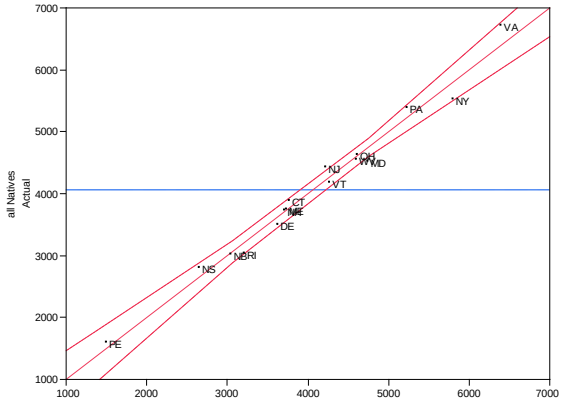
PLANTS
R^2 = 0.95



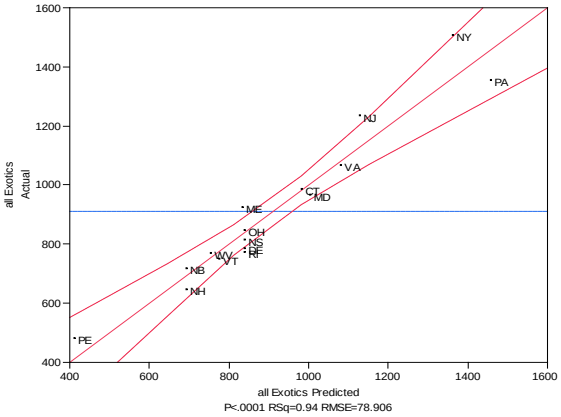
VERTEBRATES
R^2=0.87



INVERTEBRATES
R^2 = 0.88



NATIVES SPECIES ONLY
R^2 = 0.97



INTRODUCED SPECIES ONLY R^2 = 0.91

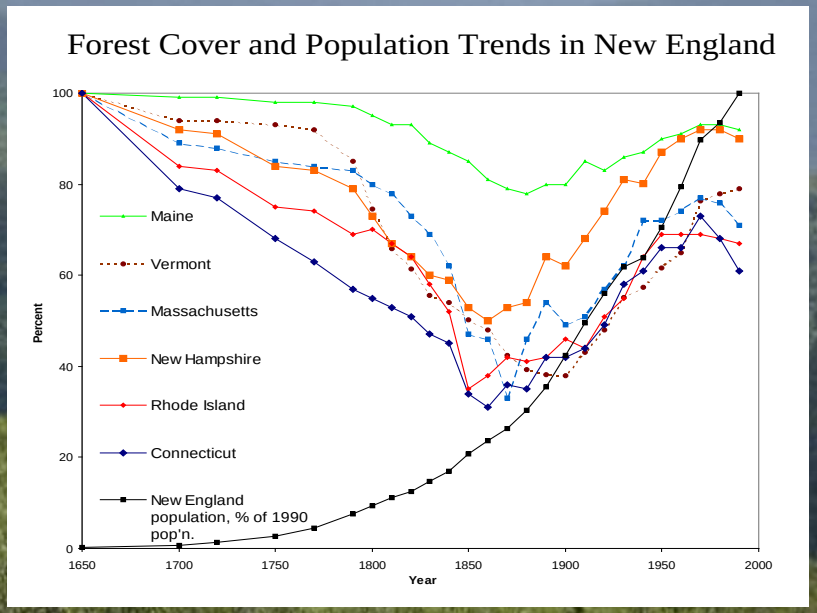
Remarkably strong relationship considering:

-functional extinction: chestnut, wolf, cougar, woodland caribou

-presently 31% of flora and 10% of vertebrate fauna are exotic

-hundreds of species range shifts

13,530 species
8,223 plants
5,307 animals
523 vulnerable



CONSERVING THE STAGE:

Create arenas for evolution not museums of the past.

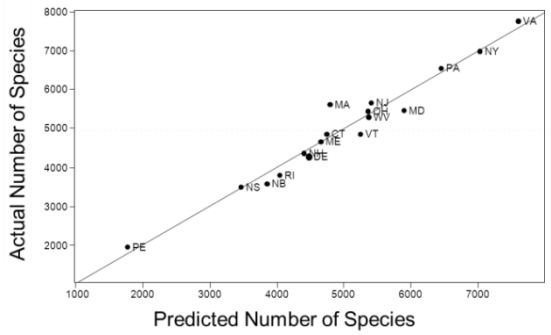
OLD:

Cattail *(Typha latifolia)* – Marsh Marigold *(Caltha palustris)* marsh
Cattail (*Typha angustifolia)* – Bullrush *(Shoenoplectus spp.)* marsh

NEW:

Freshwater marsh ecosystem on shale at low elevation.
Freshwater marsh ecosystem on granite at high elevation

Limestone valley bottom forest at low elevation
Shale slope woodland at moderate elevations



Sedimentary (quartzite)

Granite

Coastal Sand

Limestone

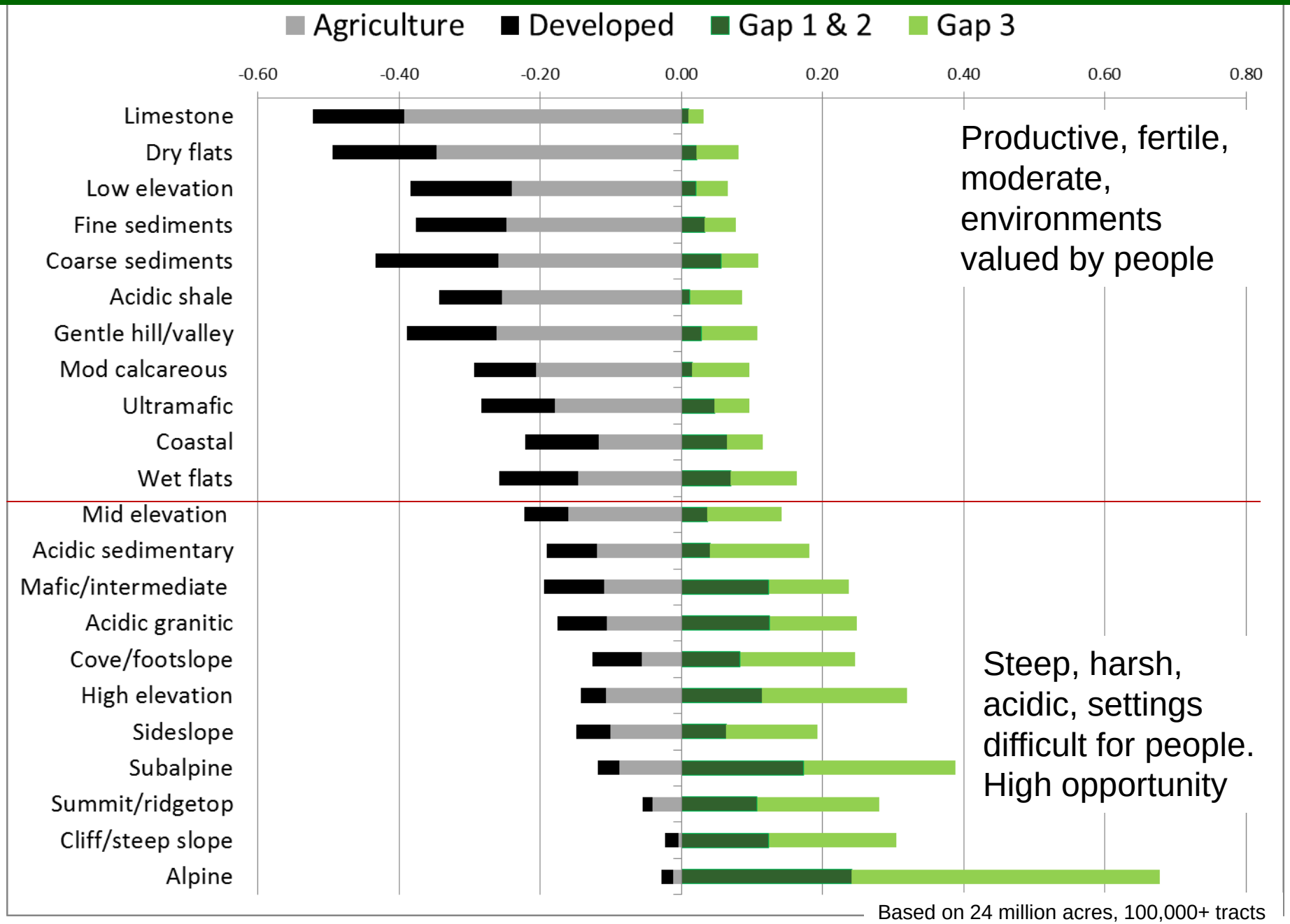
Fine Silt

Ultramafic (serpentine)

Shale

Coarse Sand

Are we already Conserving the Stages?



Based on 24 million acres, 100,000+ tracts

It is still about species

Baseball analogs:

Team remains but players change from year to year.

Functional group: positions

Needs the ballpark and needs the network of other ballparks

Even though players change, people obsess over team composition

Best predictions are always full of surprises.

Farm system

Identify and Conserve Natural strongholds.

How do we Evaluate Physical Habitats?

Species move, Ecosystems transform”

Steep slopes \ Cliffs

Coves

Summits

Flats and gentle slopes (Fo

Tidal marsh & Beach

Riparian

Rivers & Stream

Freshwater wetlands

Estimating the resilience of a place

Resilience: Definition

The capacity for renewal in a dynamic environment

- Gunderson 2000

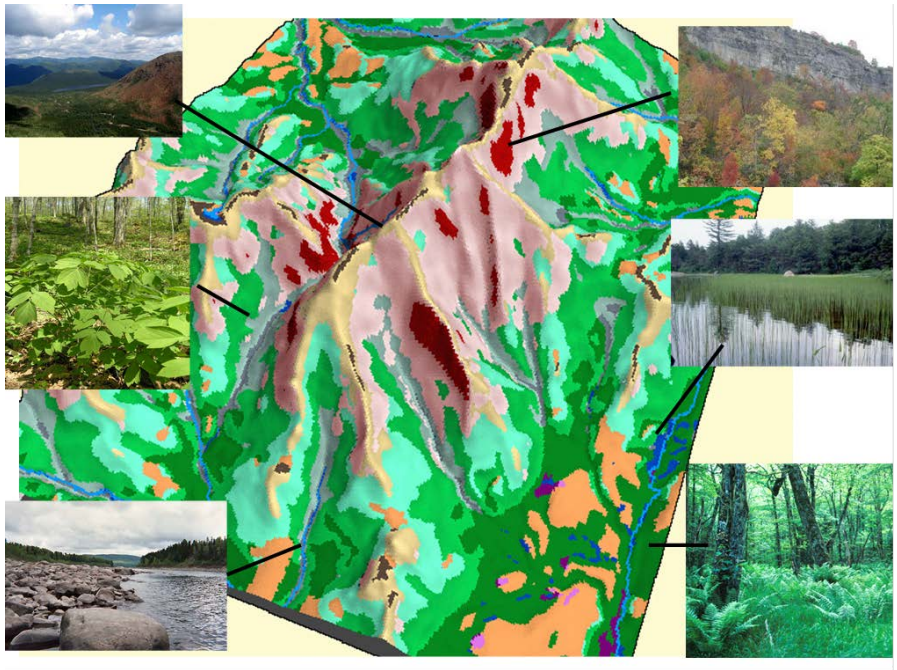
Highly Vulnerable
Limited capacity to adapt
Disrupted function, low diversity
Few options and alternatives

Highly Resilient
Large capacity to adapt
Sustain function and diversity
Many options and alternatives

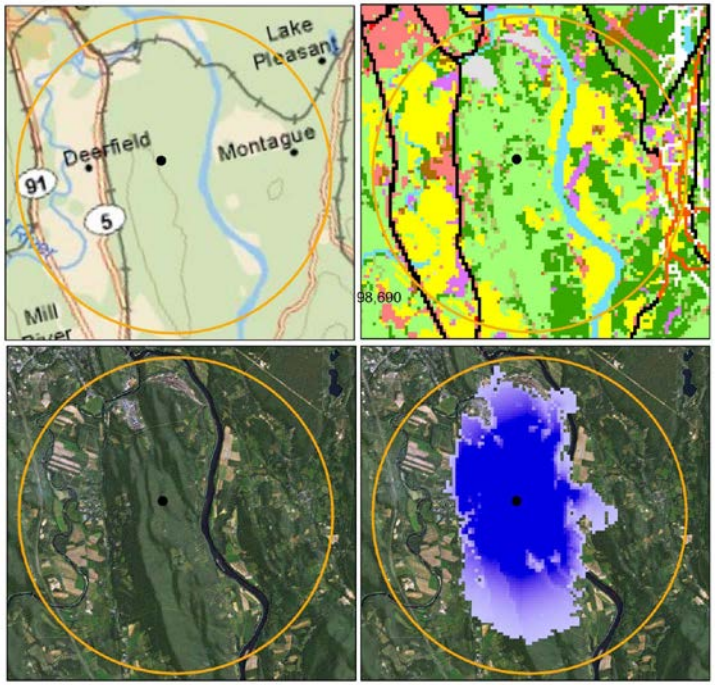
Resilient site: Has characteristics that maintain ecological functions and will likely sustain a diversity of species even as the composition and ecological processes change.

What makes a Site Resilient?

Complex Landscapes
with many “micro-climates”

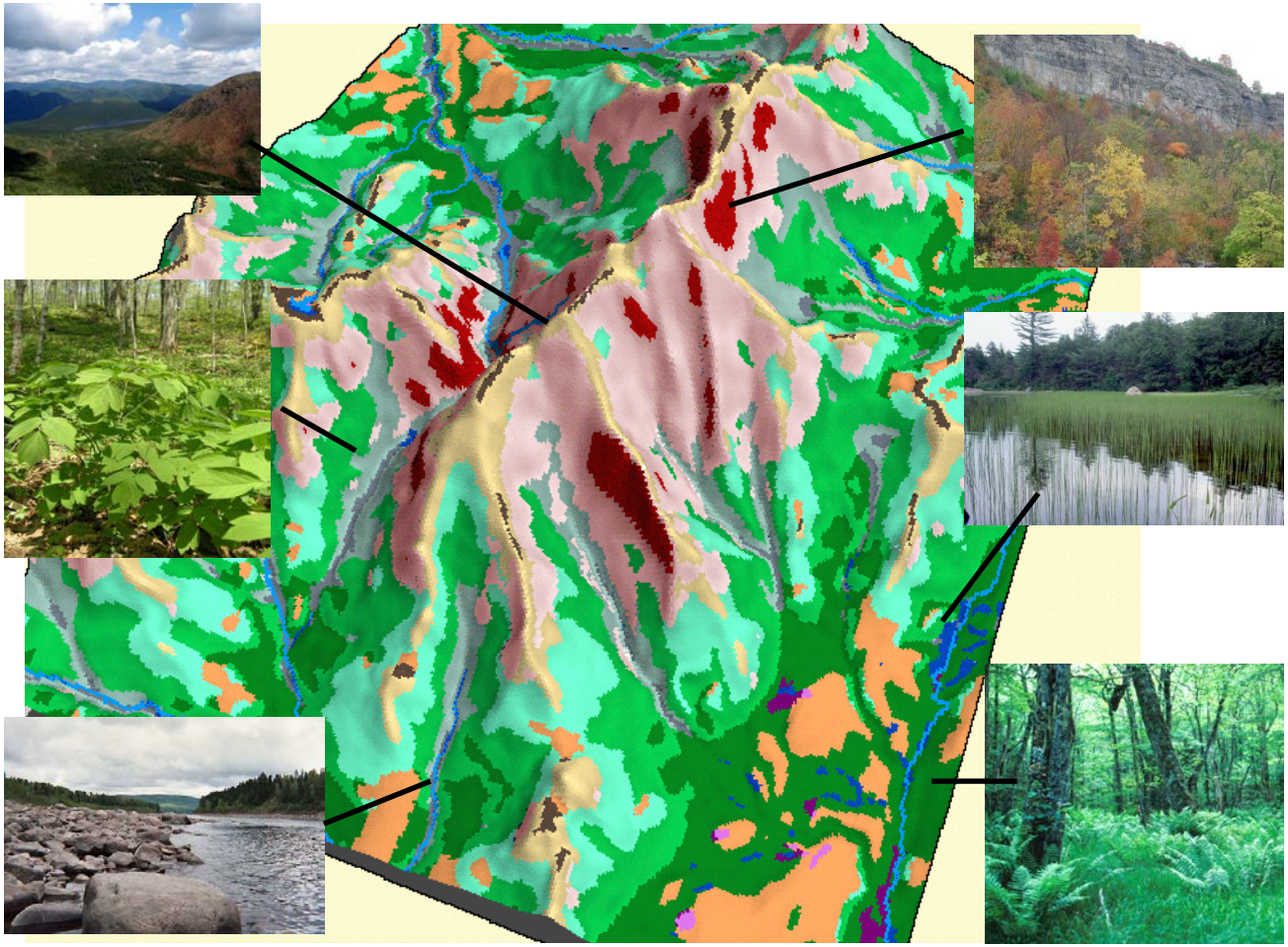


Permeable Landscapes
that are locally connected



Landscape Complexity

Landforms control the distribution of moisture, nutrients and climatic effects, create “microclimate buffering”



More Heterogeneity = more options for species to move and rearrange at a given site

Ridges
Summits
Side-slopes
Toe-slopes
Cliffs
Coves
Valleys
Wetlands

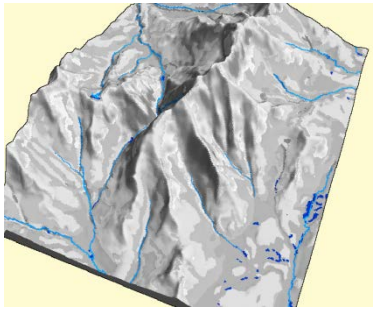
Willis and Bhagwat, 2009. **Biodiversity and Climate Change**. Science , Loarie et.al. 2009. **The velocity of Climate Change** . Nature

The Landform Model

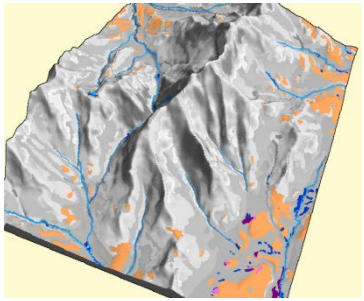
Count the number of microclimates

(8 types in the circle shown).

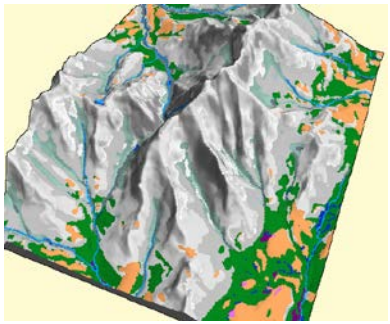
Streams & wetland



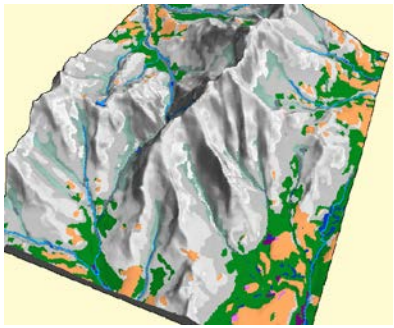
Flats & low hills



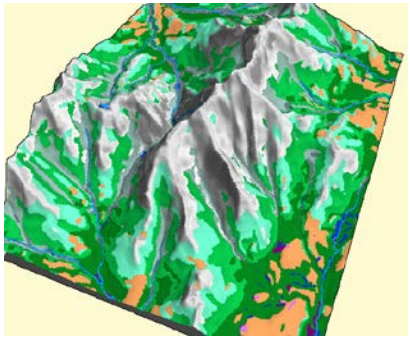
Valley/toe slope



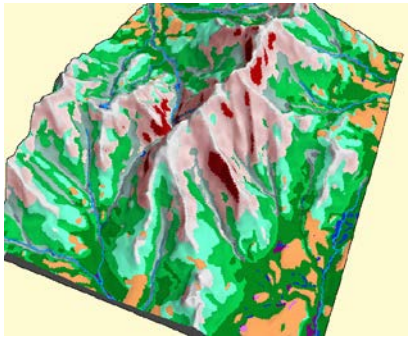
Coves and draws

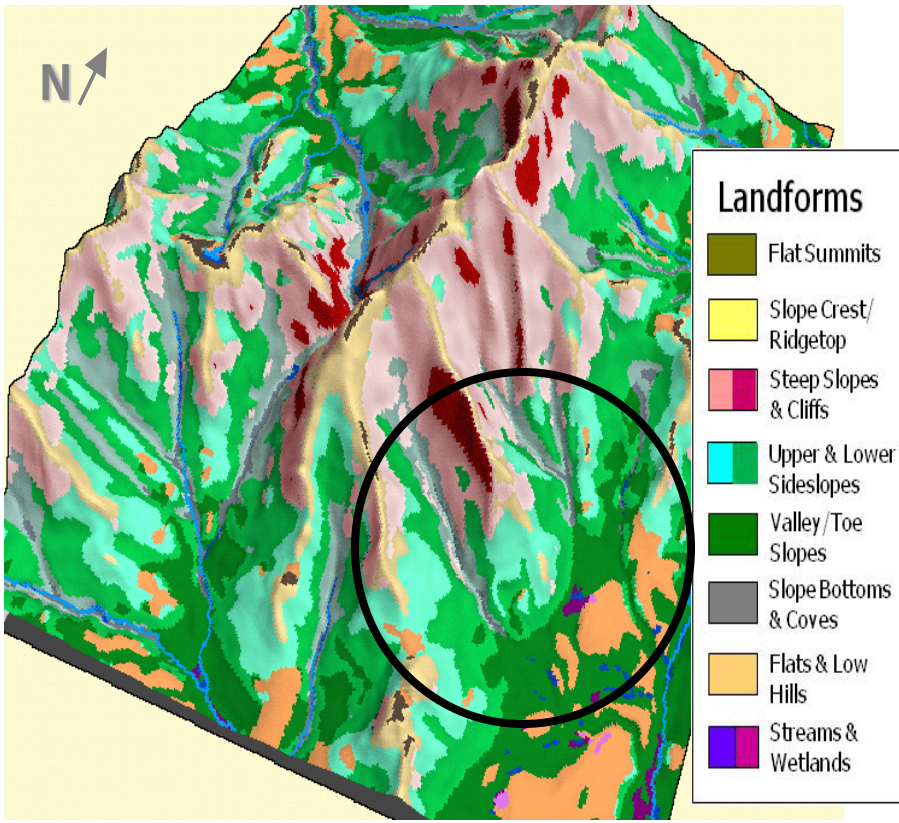


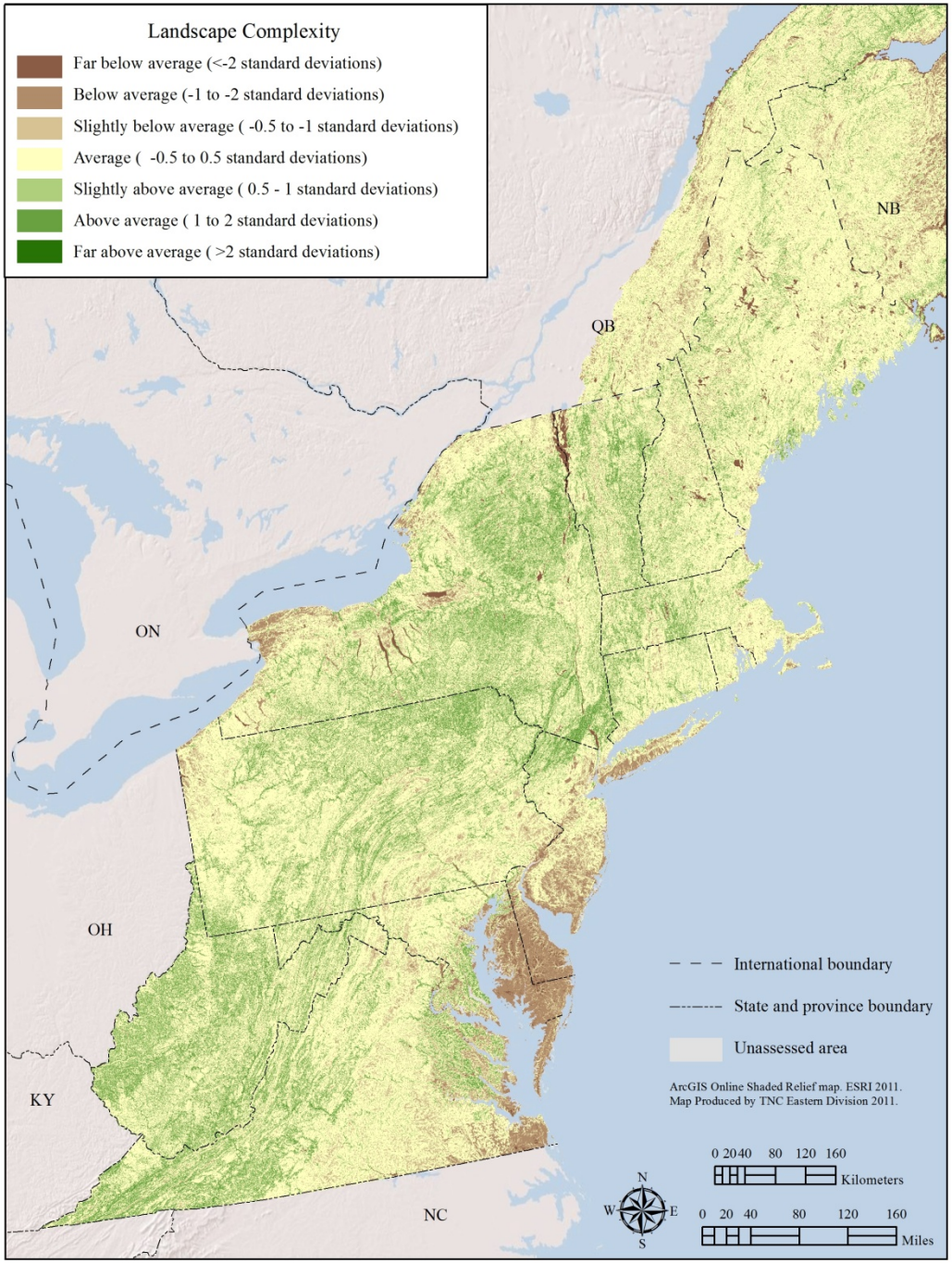
Side slopes



Cliff and steep slope





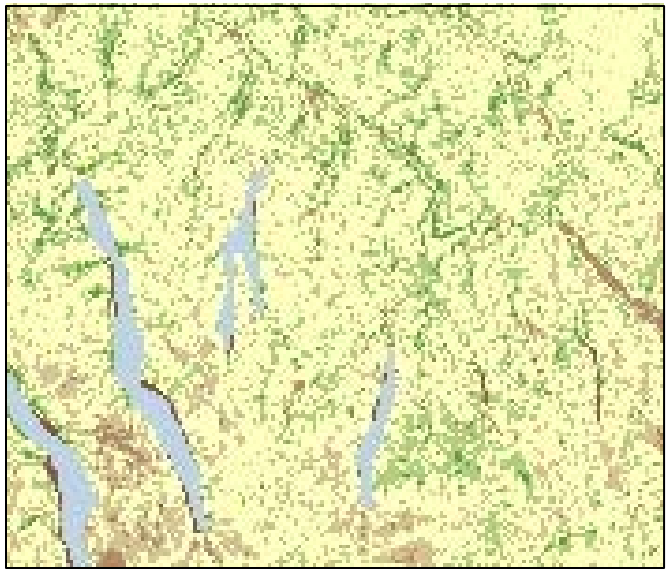


Landscape Complexity

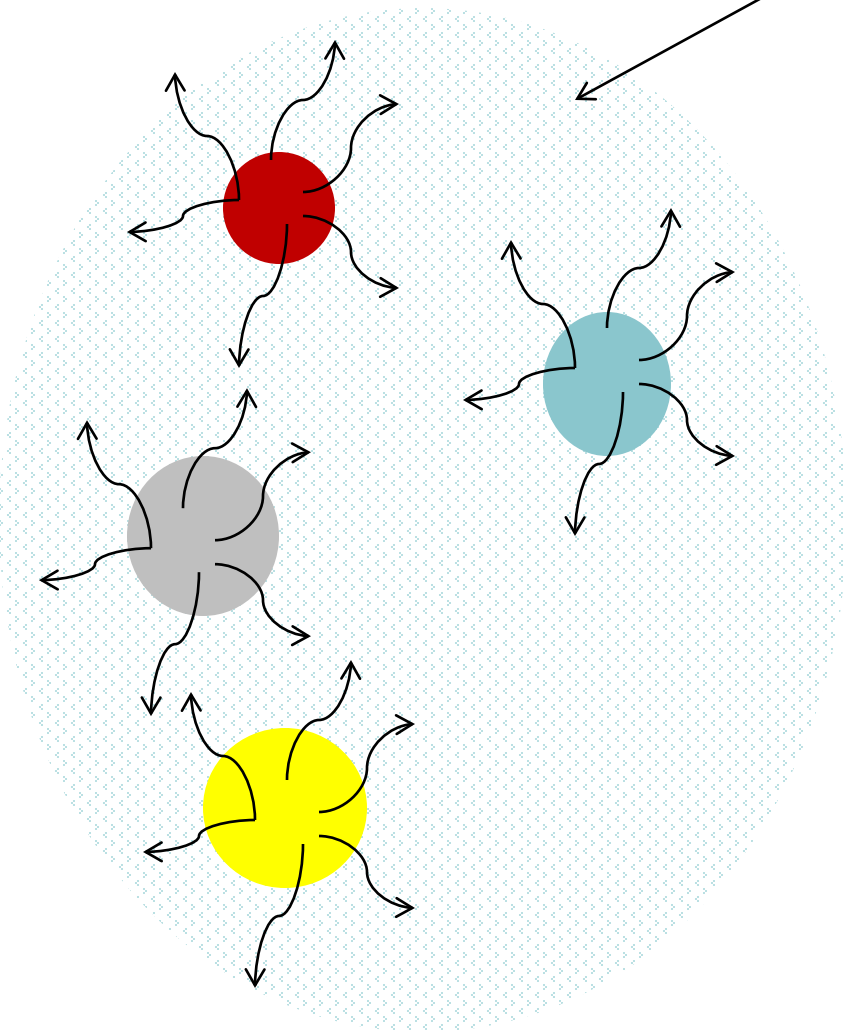
Number of landforms
Wetland density
Elevation range

For every 30 meter cell in the region

Zoom in of Finger Lakes Region



Permeability
The space in between



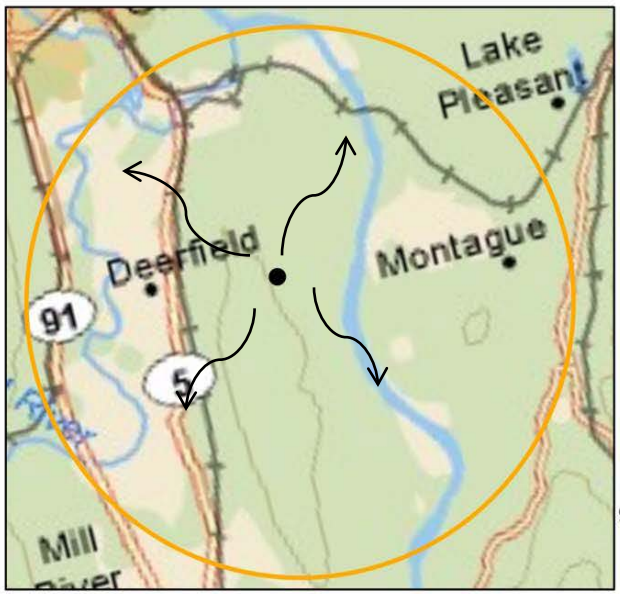
Permeability or Connectedness =

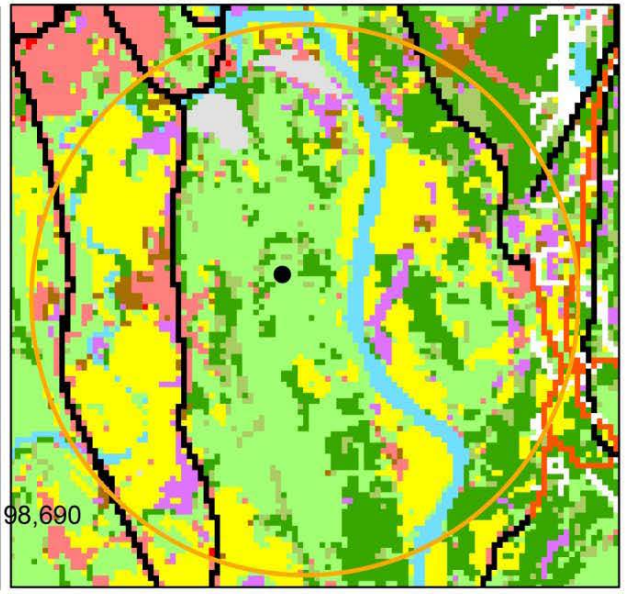
The degree to which the landscape allows for flows such as species movement, disturbances, water, fire, and other natural processes

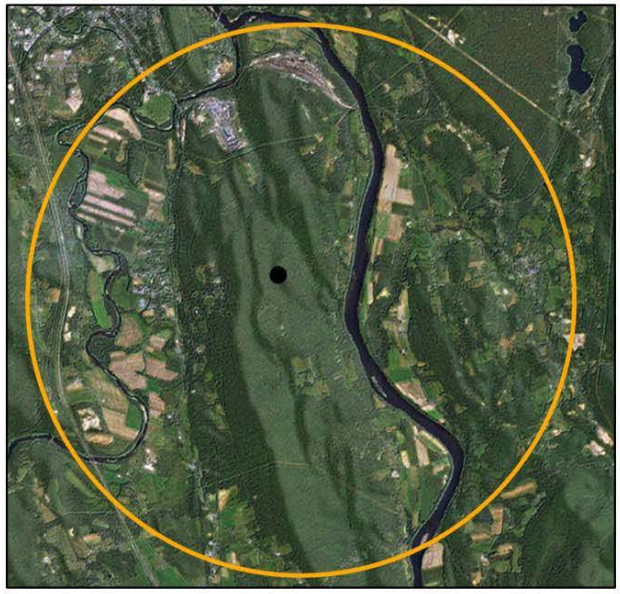
Highly Permeable Landscapes
provide many options and alternatives.

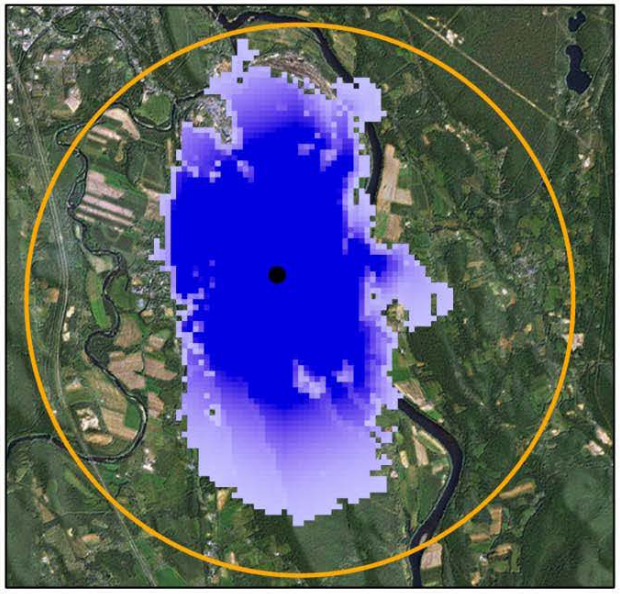
Impermeable Landscapes
Provide few options, strict channels (chutes and traps)

Permeability: Local Connectedness









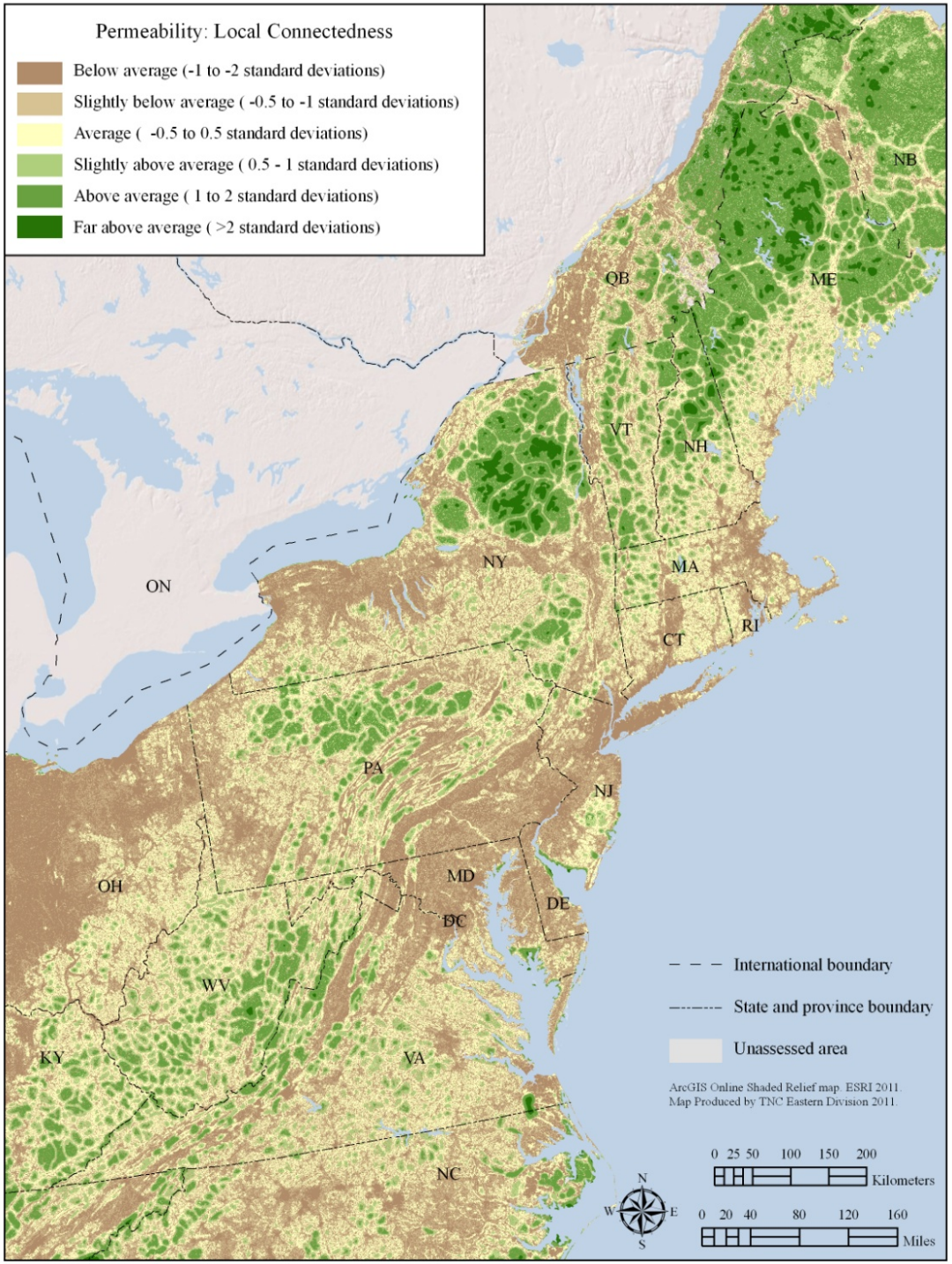
Highly Permeable areas offer many options and alternatives for movement and reorganization

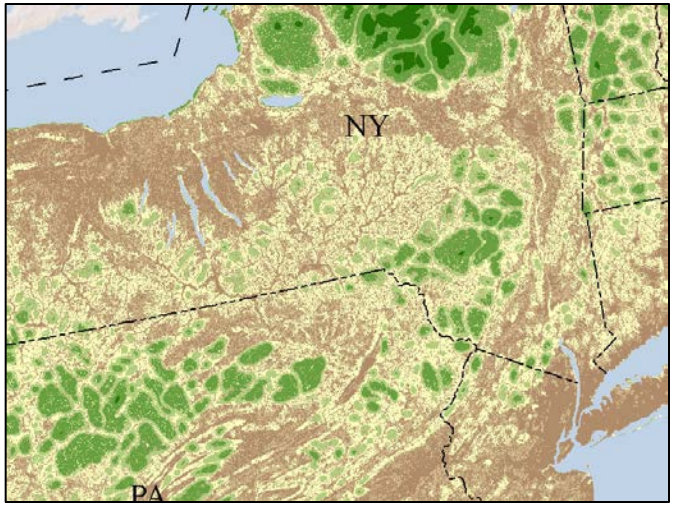
We used a resistant kernel model based on weights assigned to roads, development and agriculture

Developed by Brad Compton: UMASS

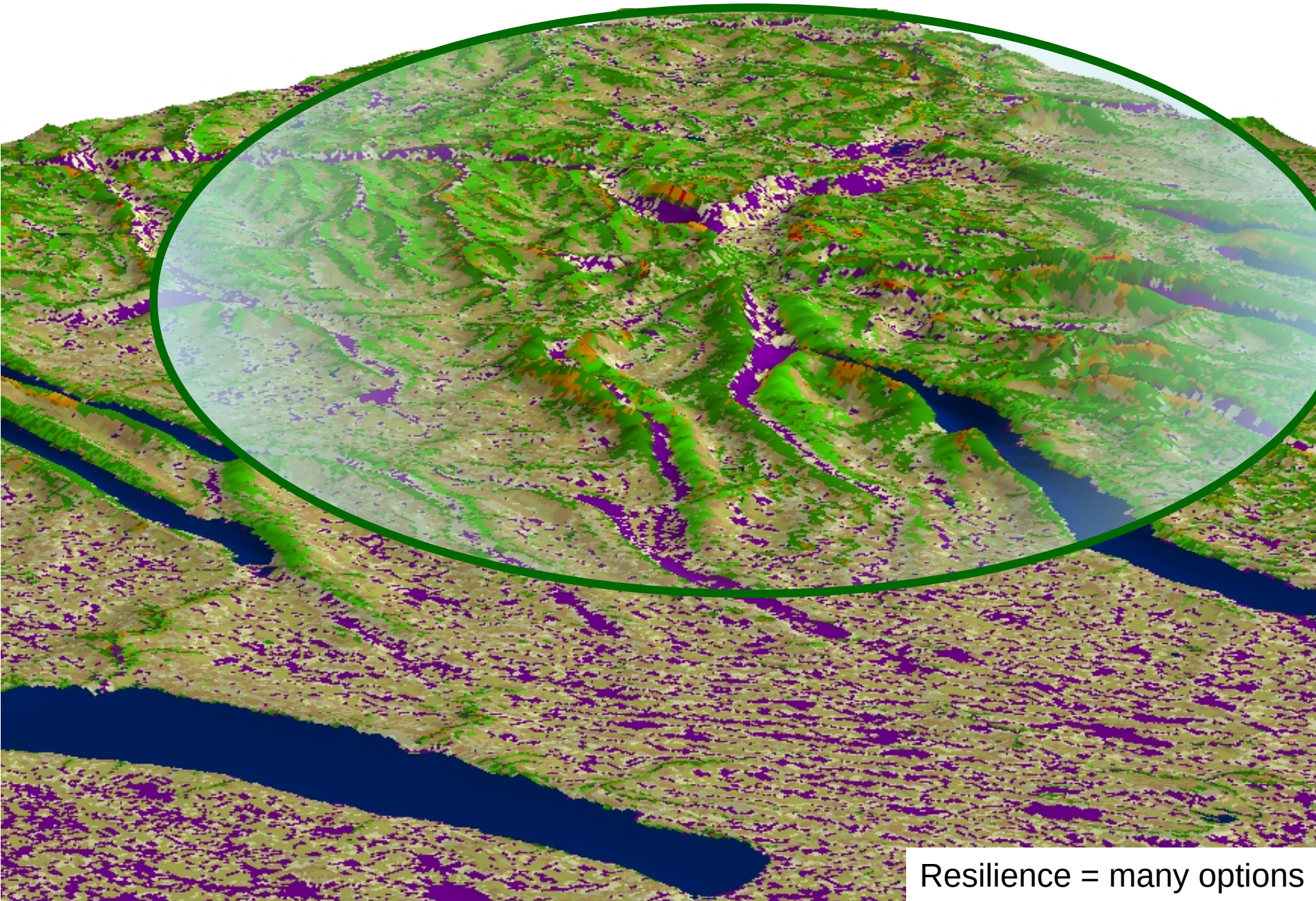
Local Connectedness

Score for every 30 m cell in the region



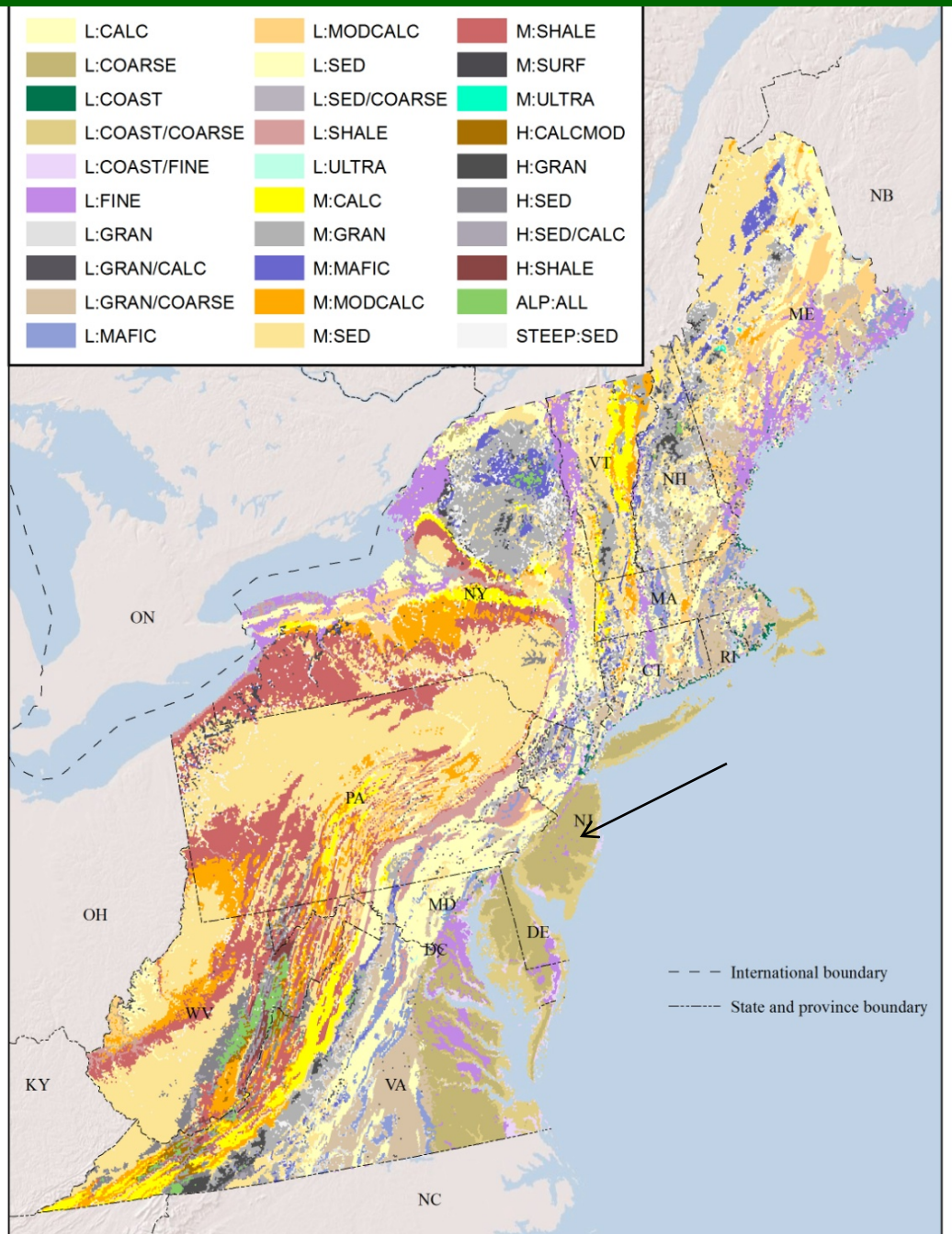


Complex and Permeable



Resilience = many options

Applying the Filter to Geophysical Settings



Mapped 27 settings

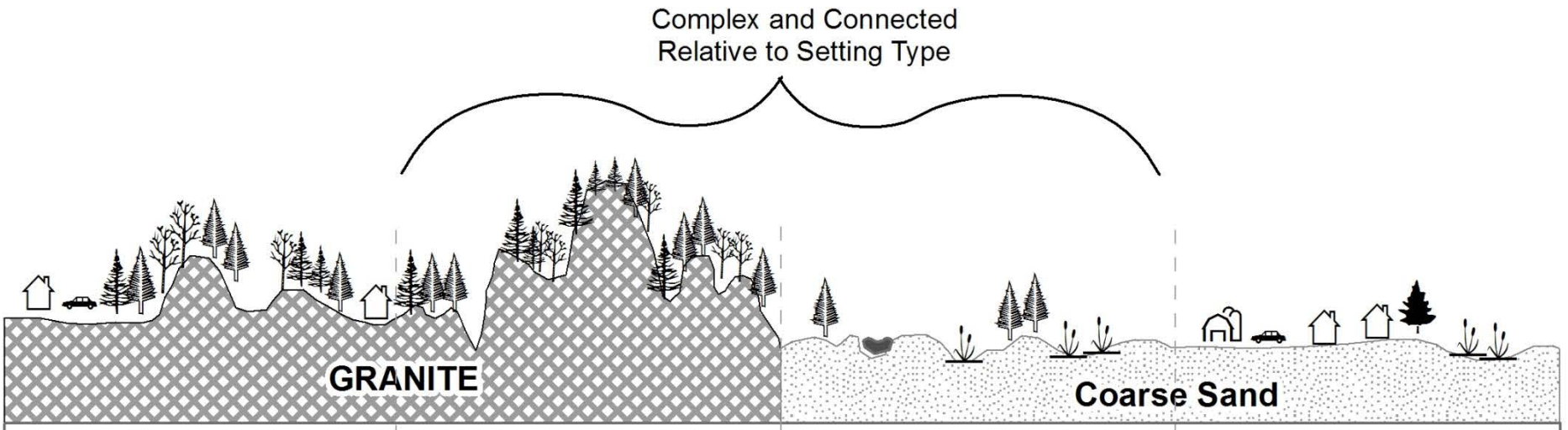
Each is a combination of a geology type and a broad elevation zone.

For Example

H:Gran = High elevation granite

L:Coarse = Low elevation coarse sand

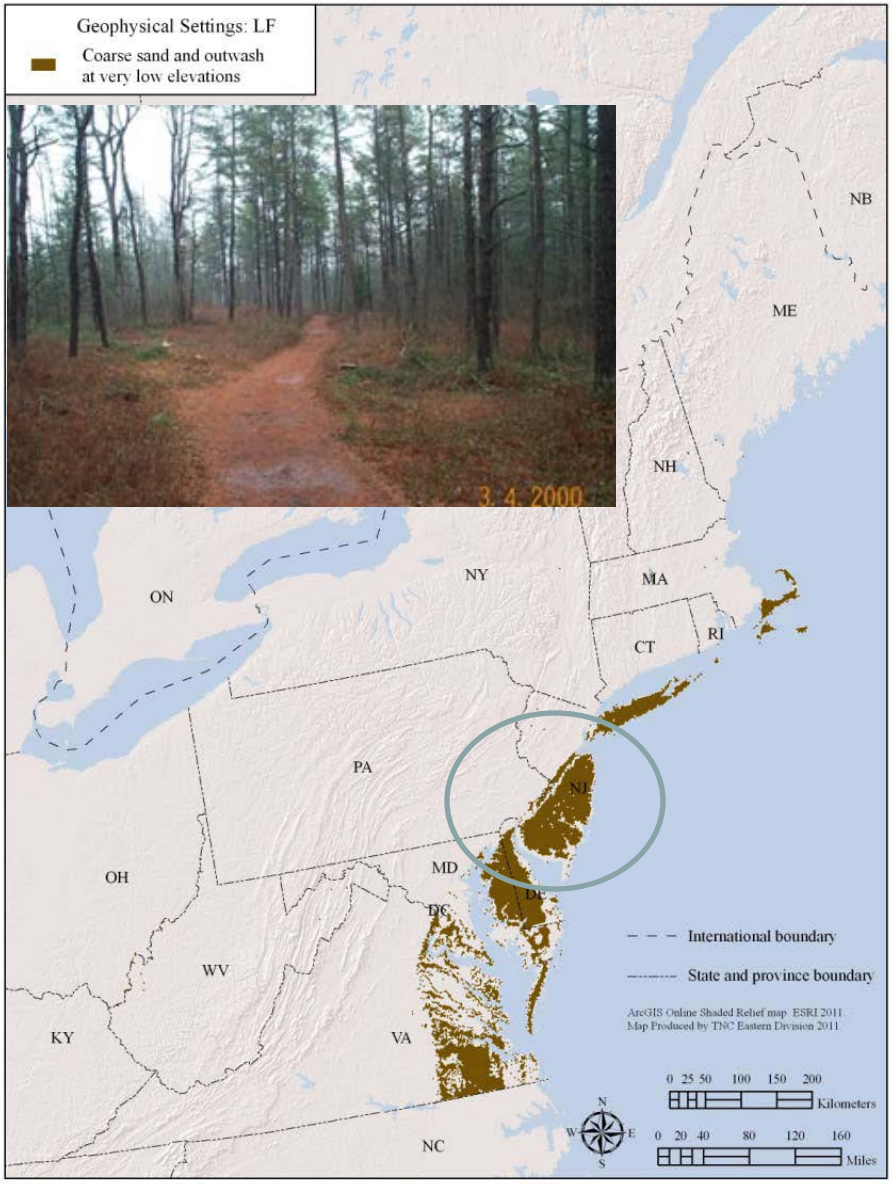
Complex and Permeable: relative to setting



Landscape Complexity Landform Variety = 5 *n sideslope *s sideslope *low hill *wet flat *dry flat Elevation Range = 100 - 300 m	**Landscape Complexity** Landform Variety = 7 *summit *cliff *n sideslope *s sideslope *slope bottom flat *wet flat *dry flat Elevation Range = 100 - 400 m	**Landscape Complexity** Landform Variety = 4 *hummuck *low hill *wet flat *dry flat Elevation Range = 0 - 22 m Wetland Denisty = medium/high	**Landscape Complexity** Landform Variety = 2 *wet flat *dry flat Elevation Range = 0 - 10 m Wetland Denisty = low
Local Connectivity Low (26 out of 100)	**Local Connectivity** High (75 out of 100)	**Local Connectivity** High (57 out of 100)	**Local Connectivity** High (8 out of 100)

Resilience = many options

Applying the Filter to a Setting: Inland Coarse Sands



Typical Systems and Communities
Dry oak-pine forest, Fire-driven Pitch pine - heath barrens,

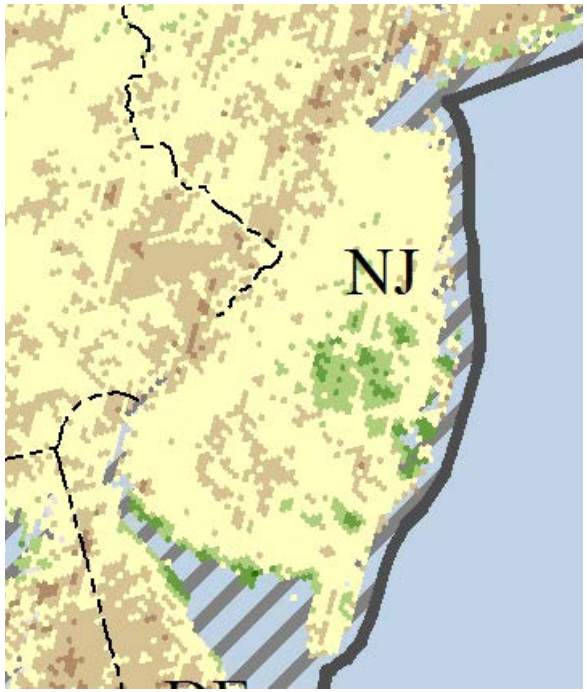
Rare Species:
Upland sandpiper, Piping plover, New England cottontail, Delmarva fox squirrel Pale false foxglove, Cuthbert turtlehead, many more

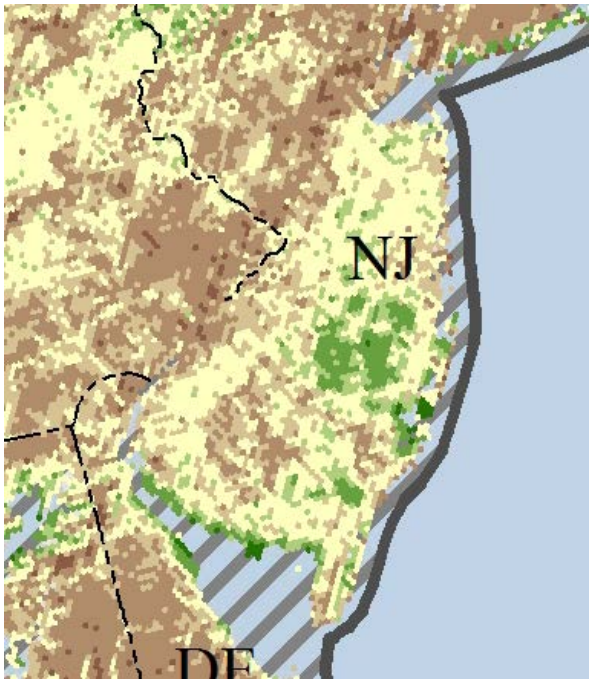
Processes:
Fire: favored by permeability. Complexity ensures mosaic structure

One of 30 settings defined by geology and elevation zone

Estimating Resilience

Complexity Z-score + **Connectedness Z-Score** = **Resilience Z-score**



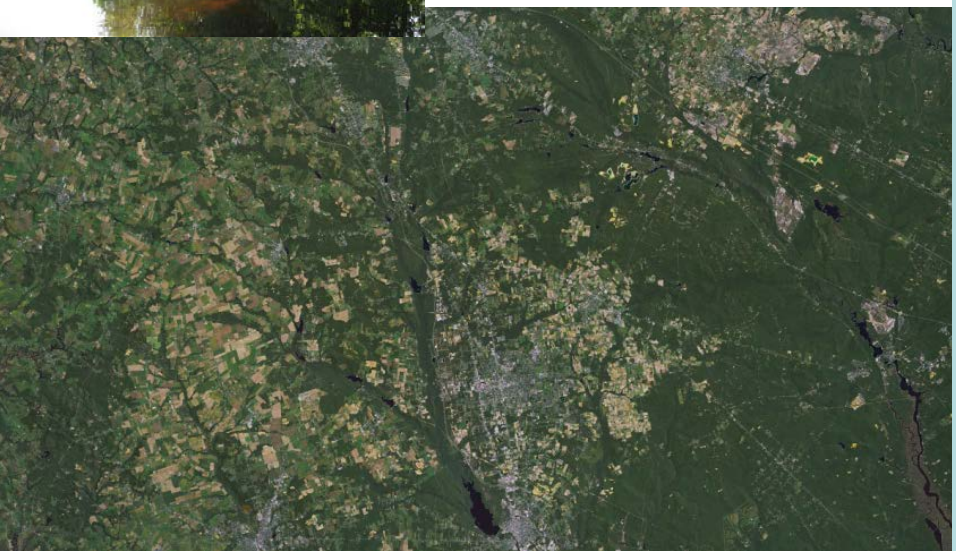


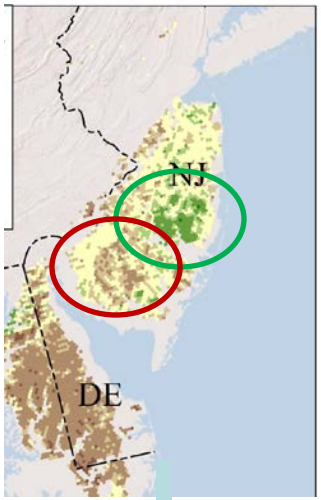
Pale Yellow = Average,
Green = Above average
Brown = Below average

Low Score
Flat and Fragmented


Wilson Lake


Ewan Orchard

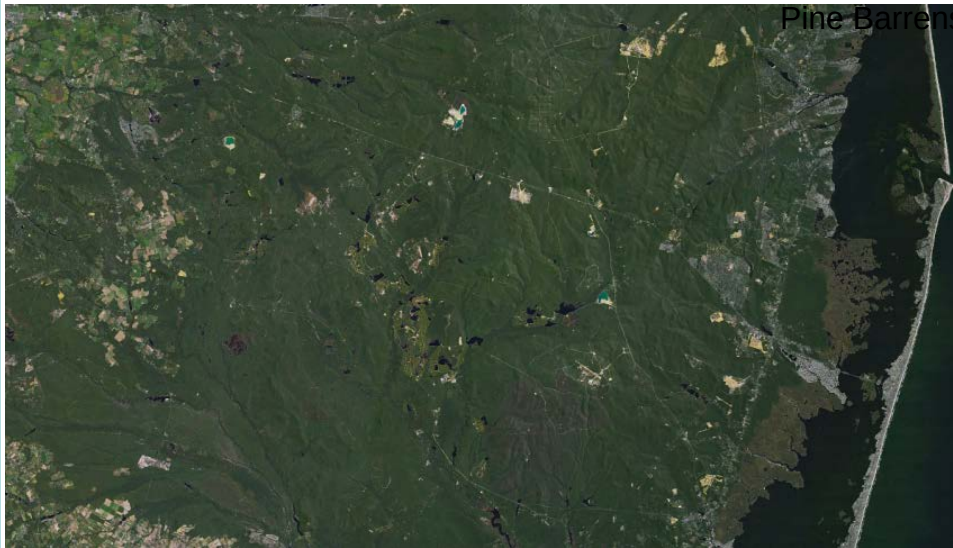




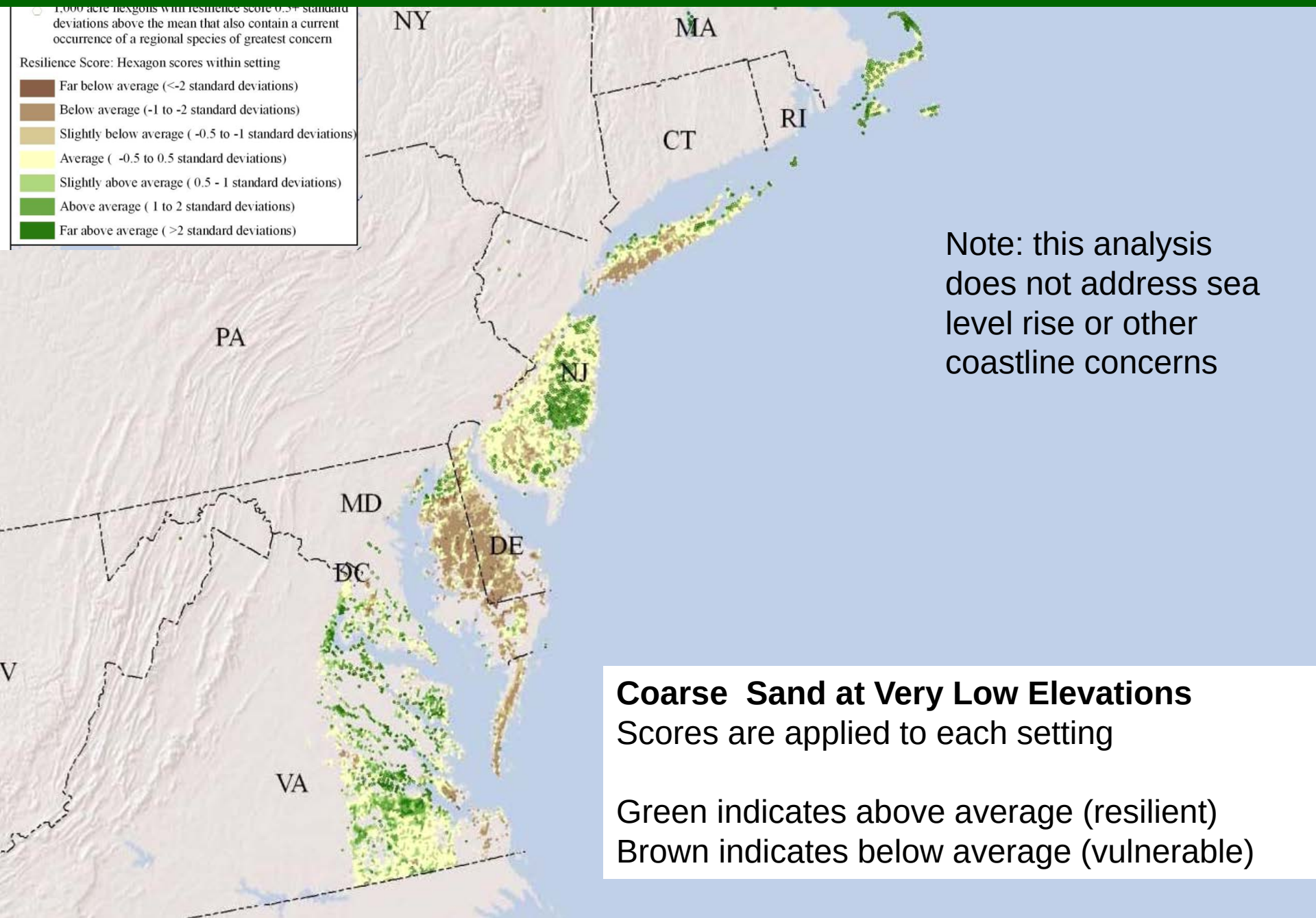
High Score
Complex and Connected


Apple Pie Hill from Tower


Chatsworth Lake


Pine Barrens

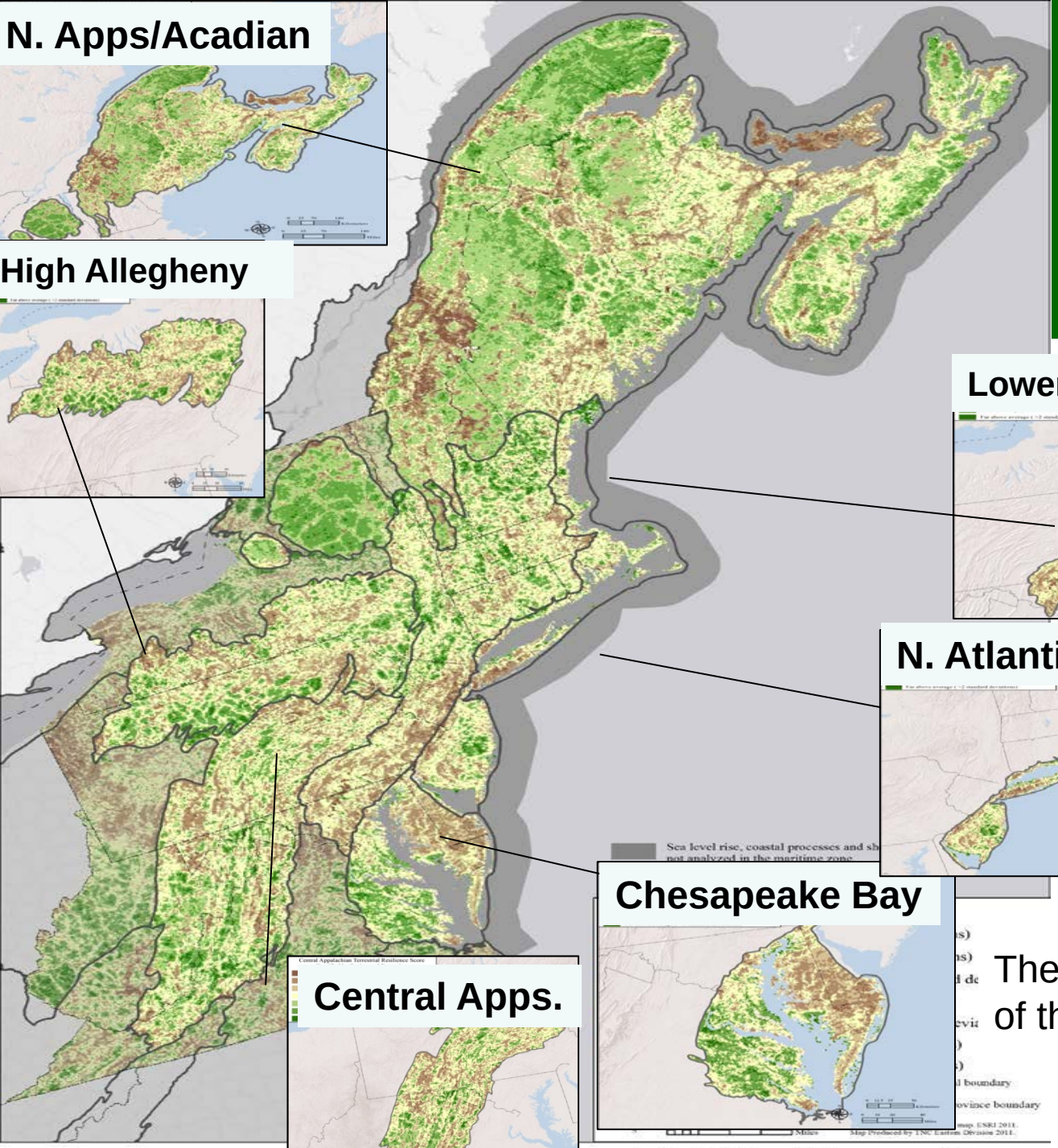
Scores for the Entire Setting



Note: this analysis does not address sea level rise or other coastline concerns

Coarse Sand at Very Low Elevations
Scores are applied to each setting

Green indicates above average (resilient)
Brown indicates below average (vulnerable)

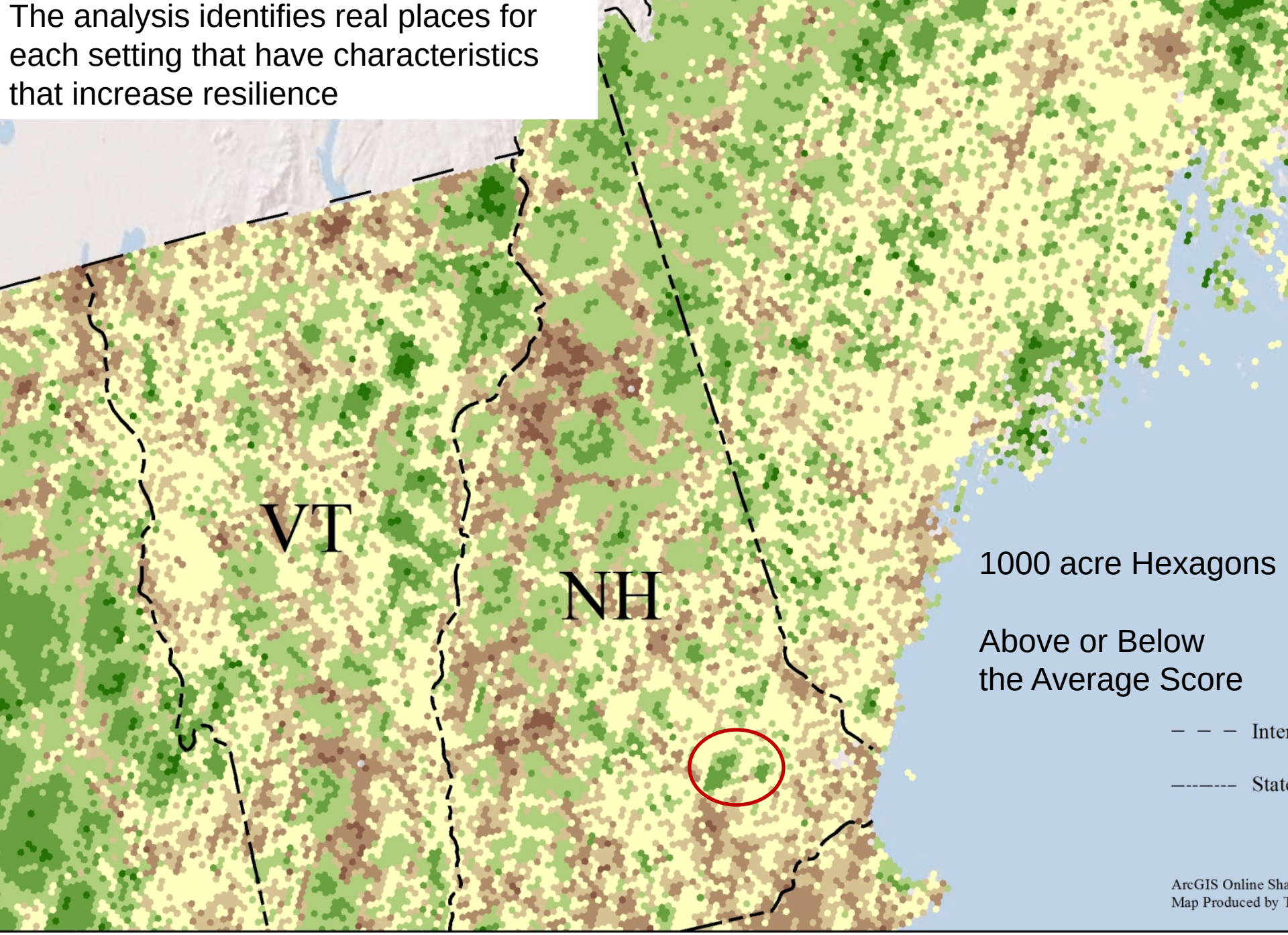


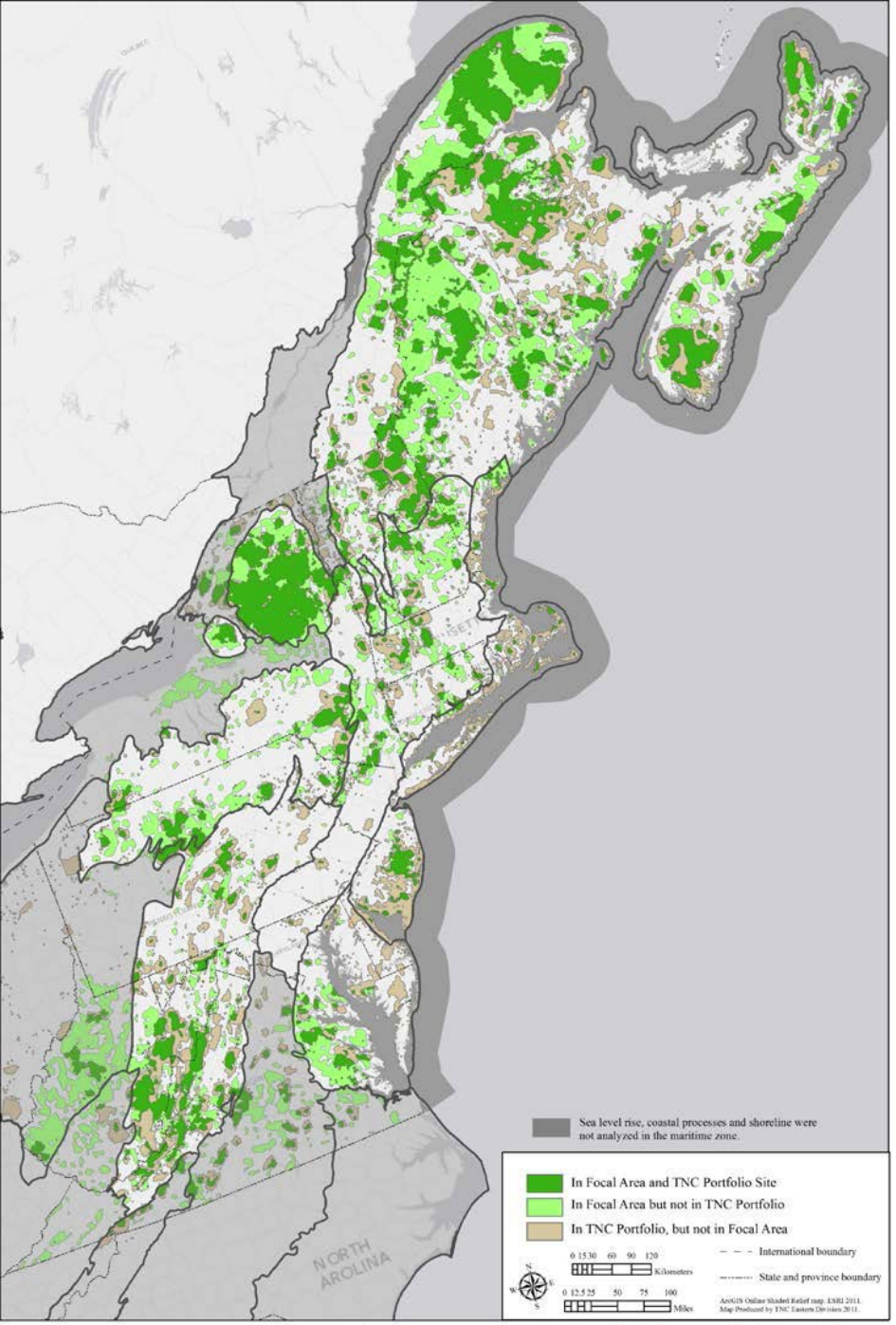
Result:

The highest scoring areas for each Geophysical Setting by ecoregion

The final map is a composite of the ecoregional maps

The analysis identifies real places for each setting that have characteristics that increase resilience





Focal Areas and TNC Portfolio Sites

Comparison with sites chosen for their high quality Biodiversity

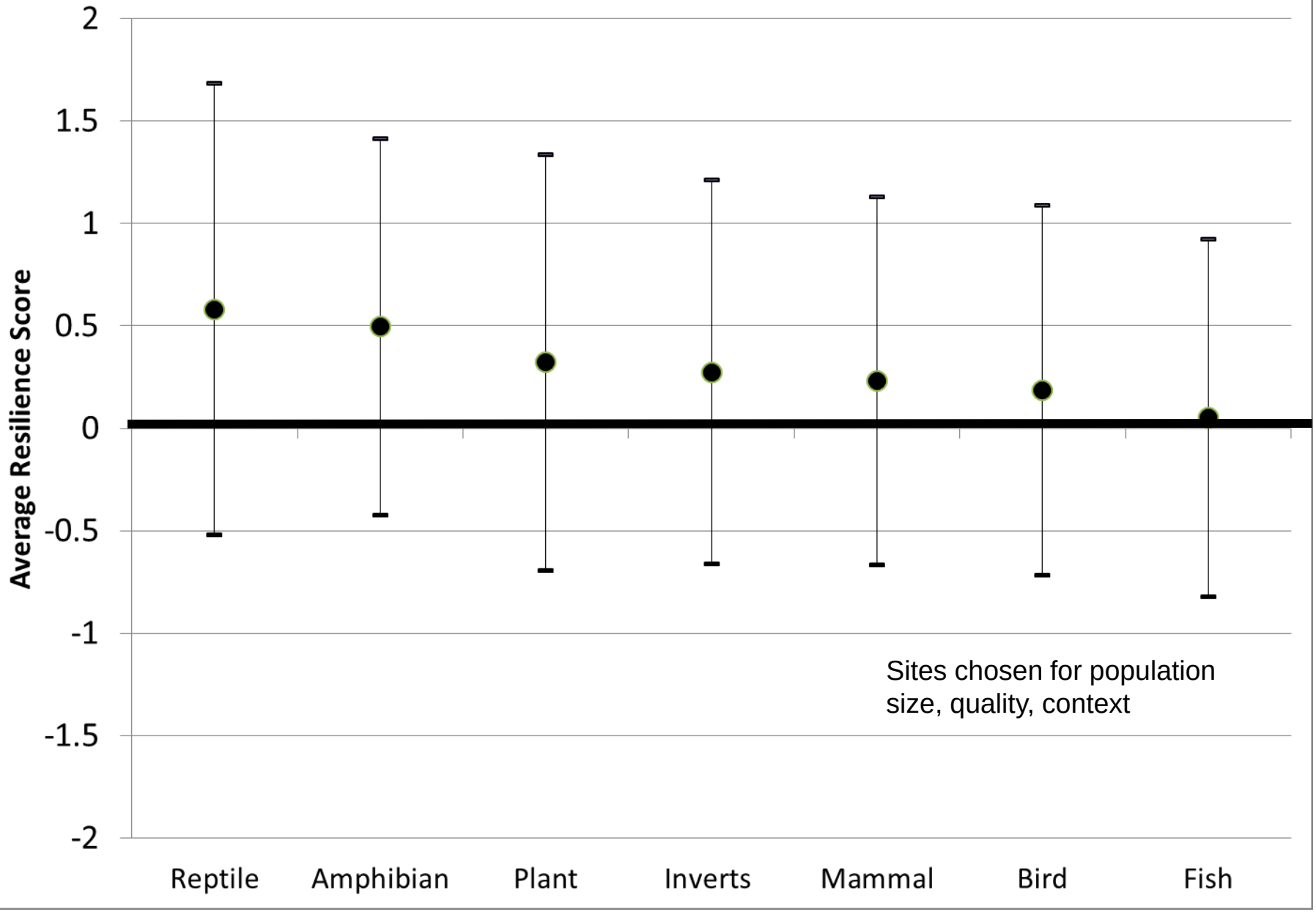
Resilient sites compared with
TNC Terrestrial Portfolio

Dark Green:
Exemplary Biodiversity and
High Terrestrial Resilience

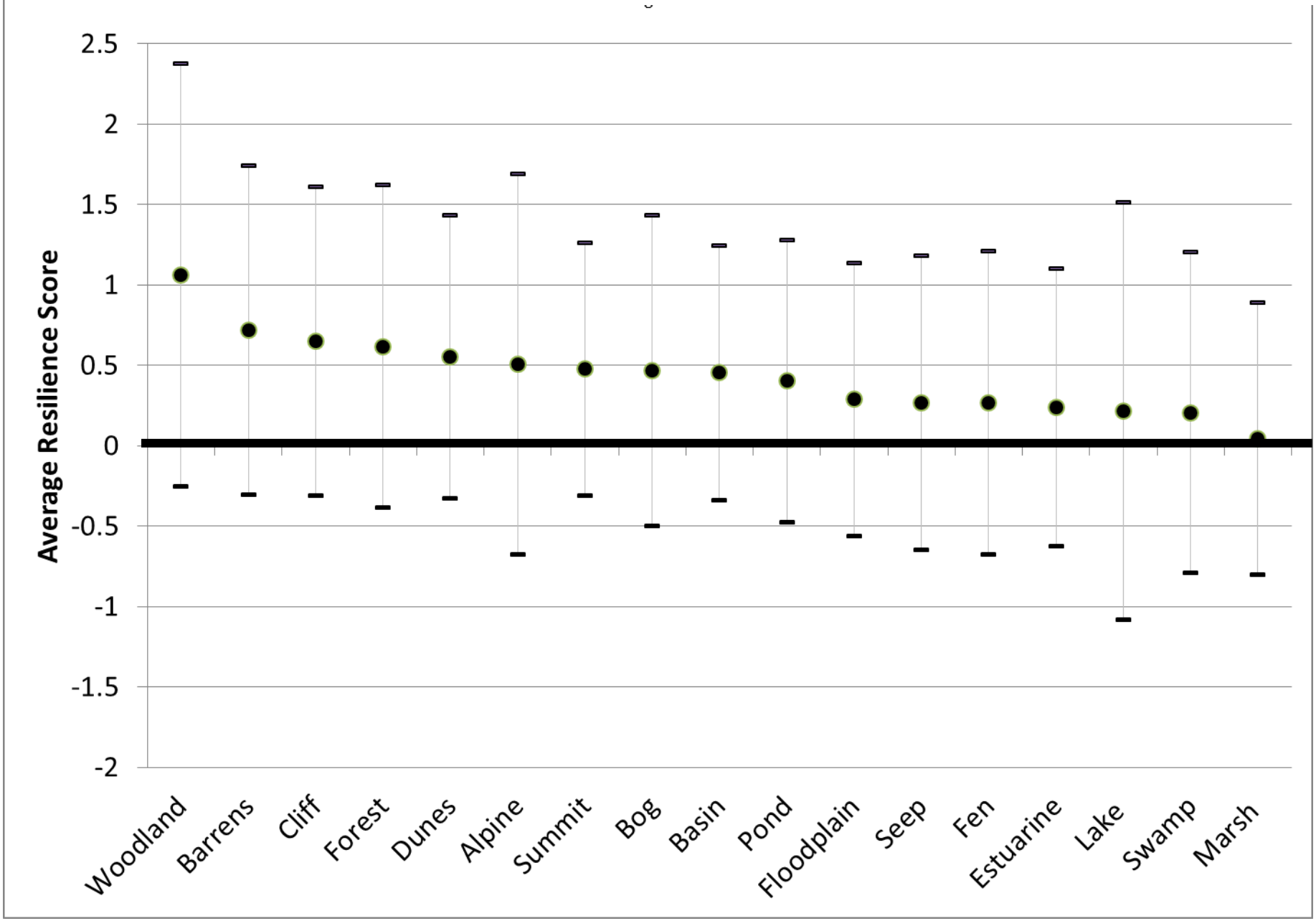
Brown:
Exemplary Biodiversity and
Low Resilience (Vulnerable)

Light Green:
High Terrestrial Resilience
no Portfolio Sites.

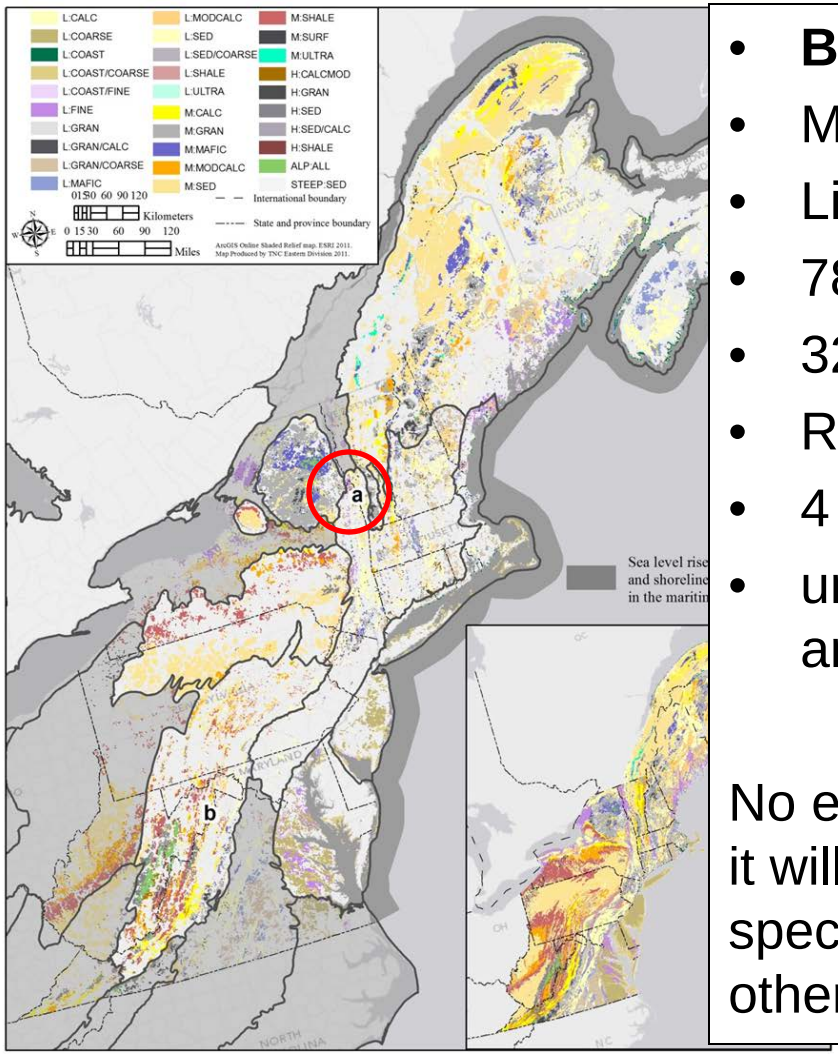
Rare Species Portfolio: **Average Resilience Score in Standard Deviations**



Natural Community Portfolio: Average Resilience Score in Standard Deviations



Natural Strongholds

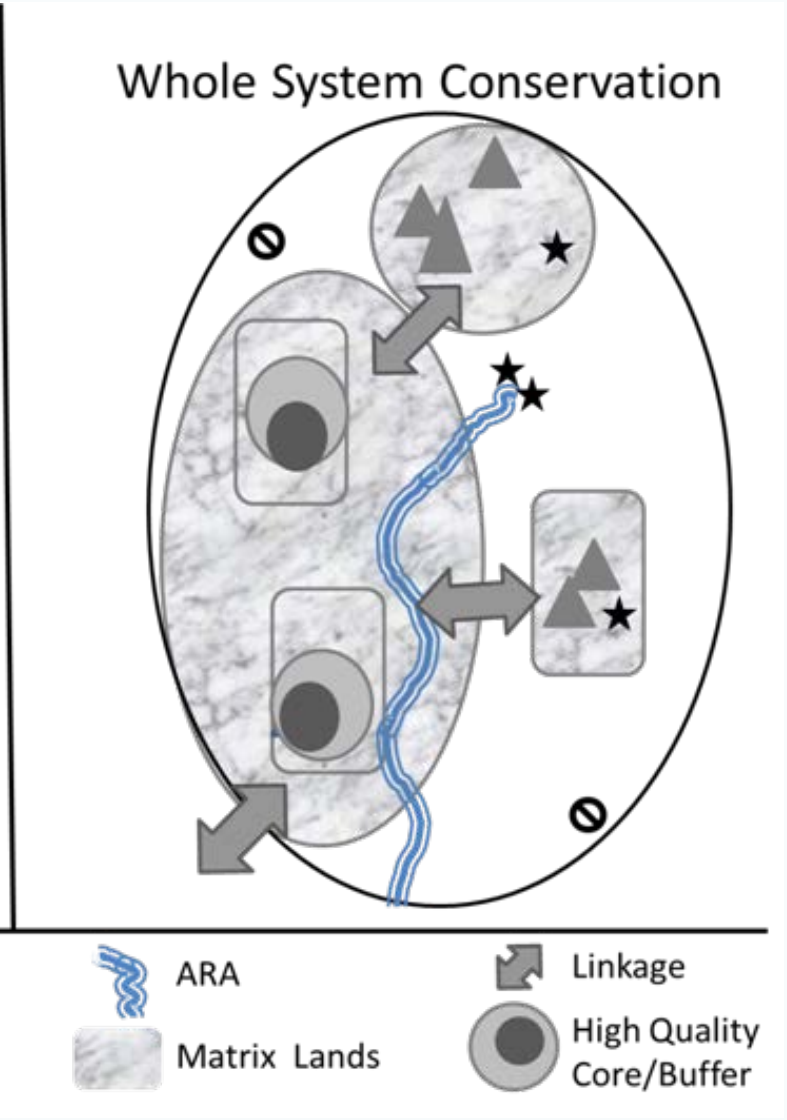


- **Blueberry Hill - Bald Mountain, Vermont**
- Mean resilience score = 1.6 SD,
- Limestone and Fine silts
- 78% confirmed by exemplary biodiversity.
- 32 natural community types,
- Rare species types: 133 plants, 6 fish,
- 4 amphibians, 4 reptiles
- uncommon birds such as upland sandpiper and long-eared owl

No expectation that it will stay the same only that it will continue to support a diverse array of species and that persistence will be longer that other sites of its type

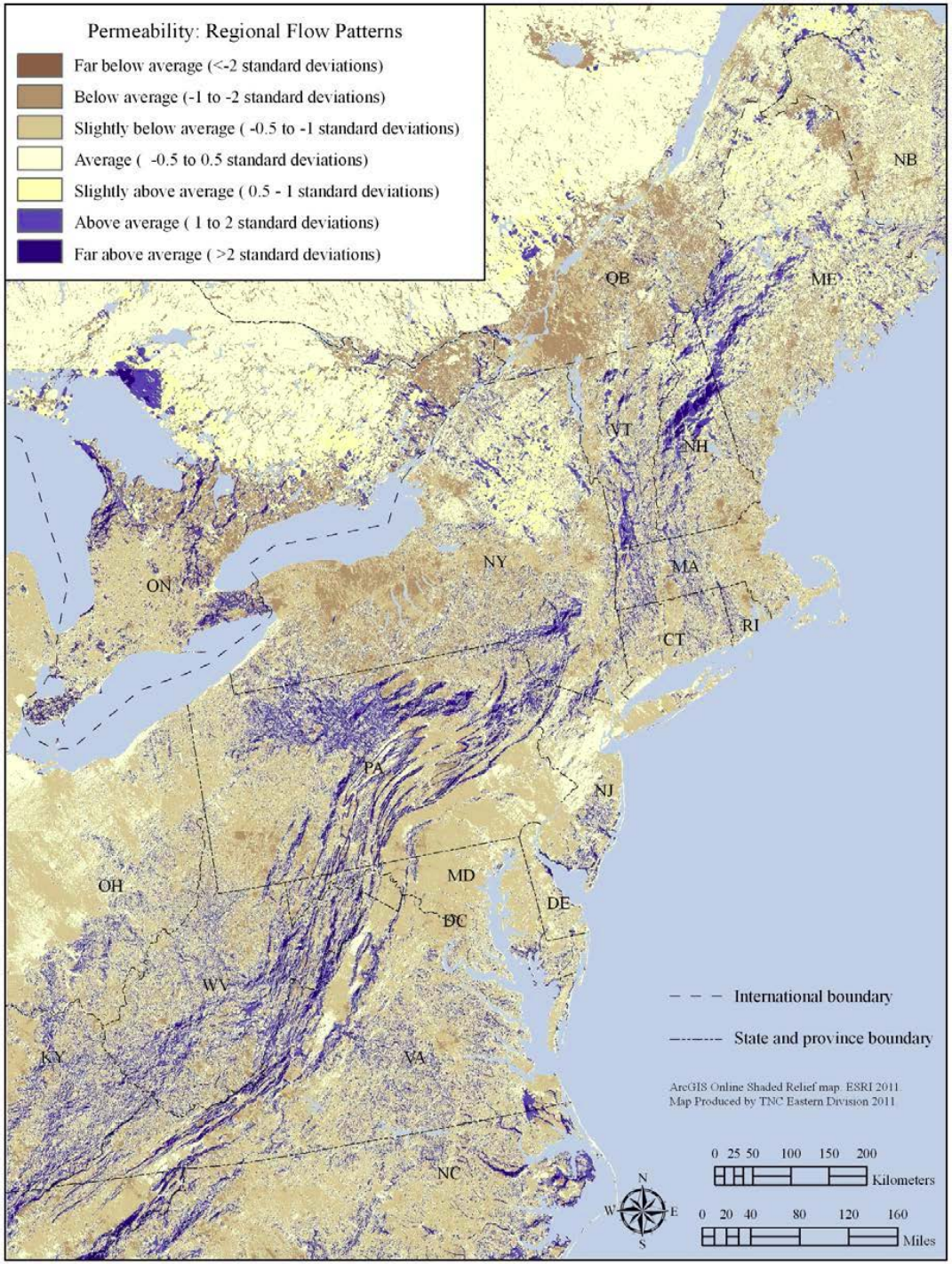
Maintain Permeable Landscapes

How do we keep all the species in play using only part of the landscape?



Regional Pinch Points

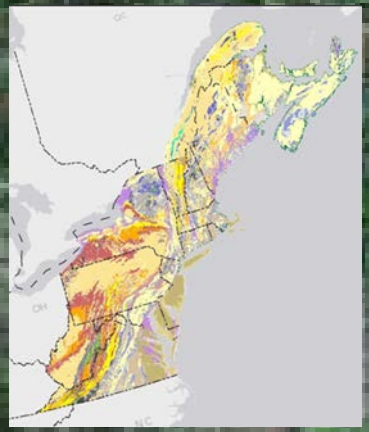
using wall-to-wall circuitscape analysis of flow concentration

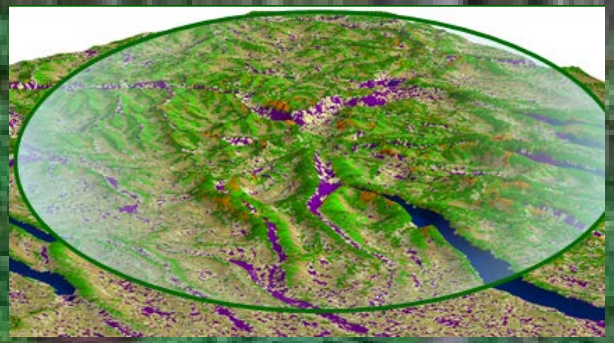


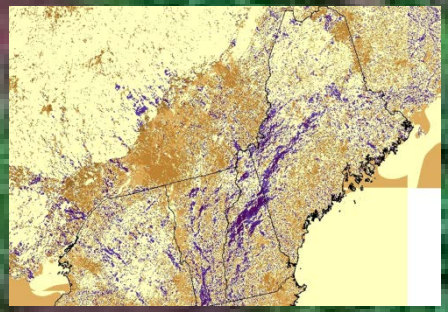
Areas in Blue have Concentrated Flow.

Areas in Brown have Blocked Flow.

Areas in White have Diffuse Flow







A Resilient Conservation Portfolio

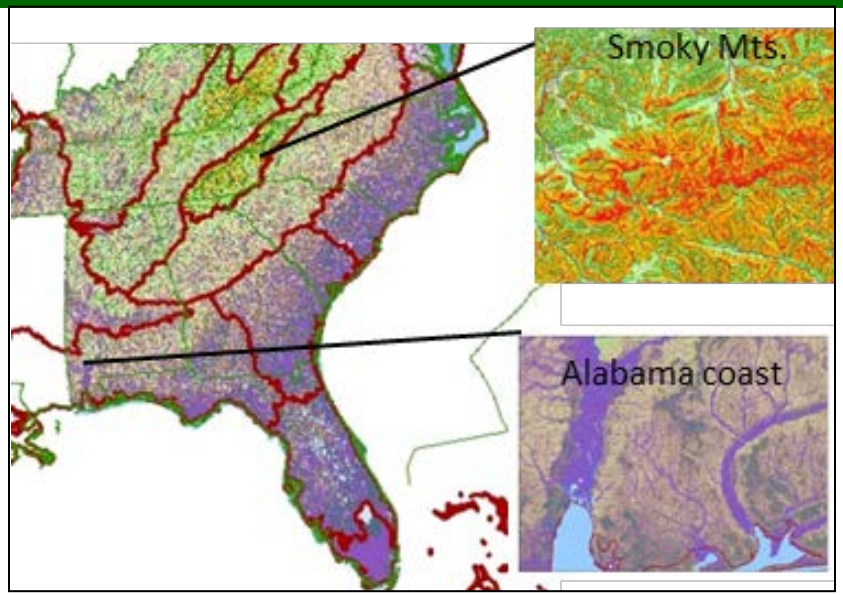
-sites representative of all geophysical settings,

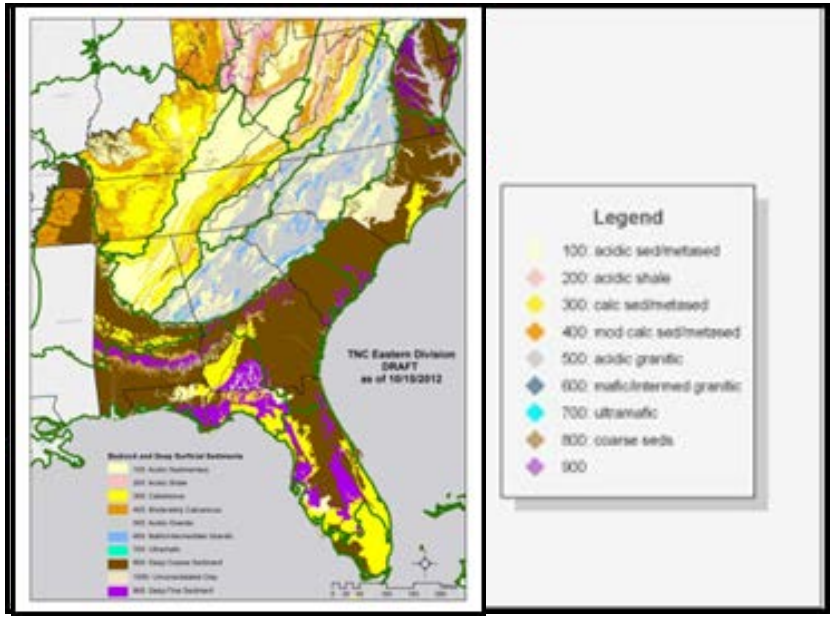
-selected for their high complexity and connectedness

-nested in a permeable landscape

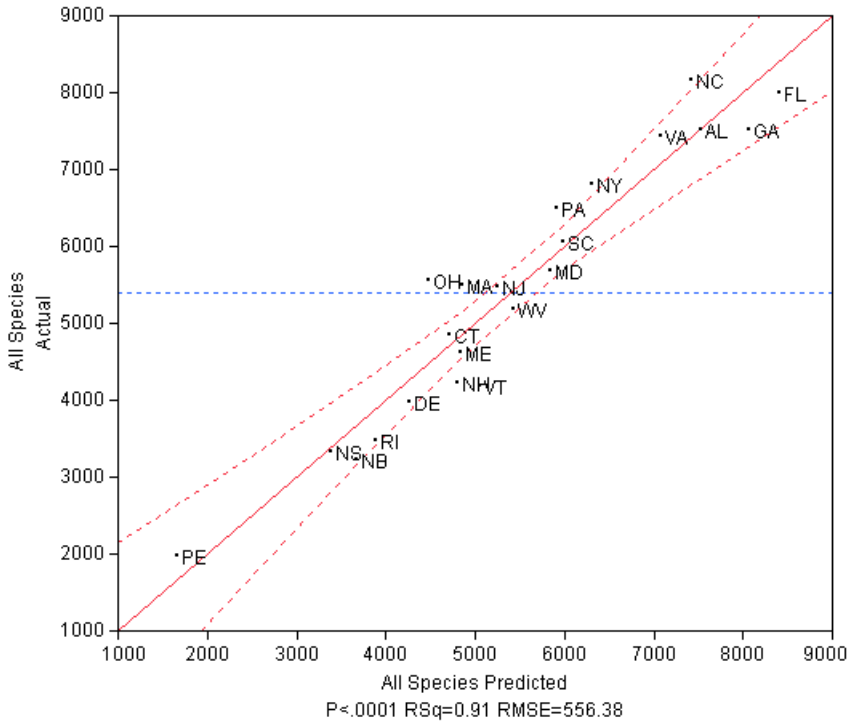
Next step: Managing for Resilience

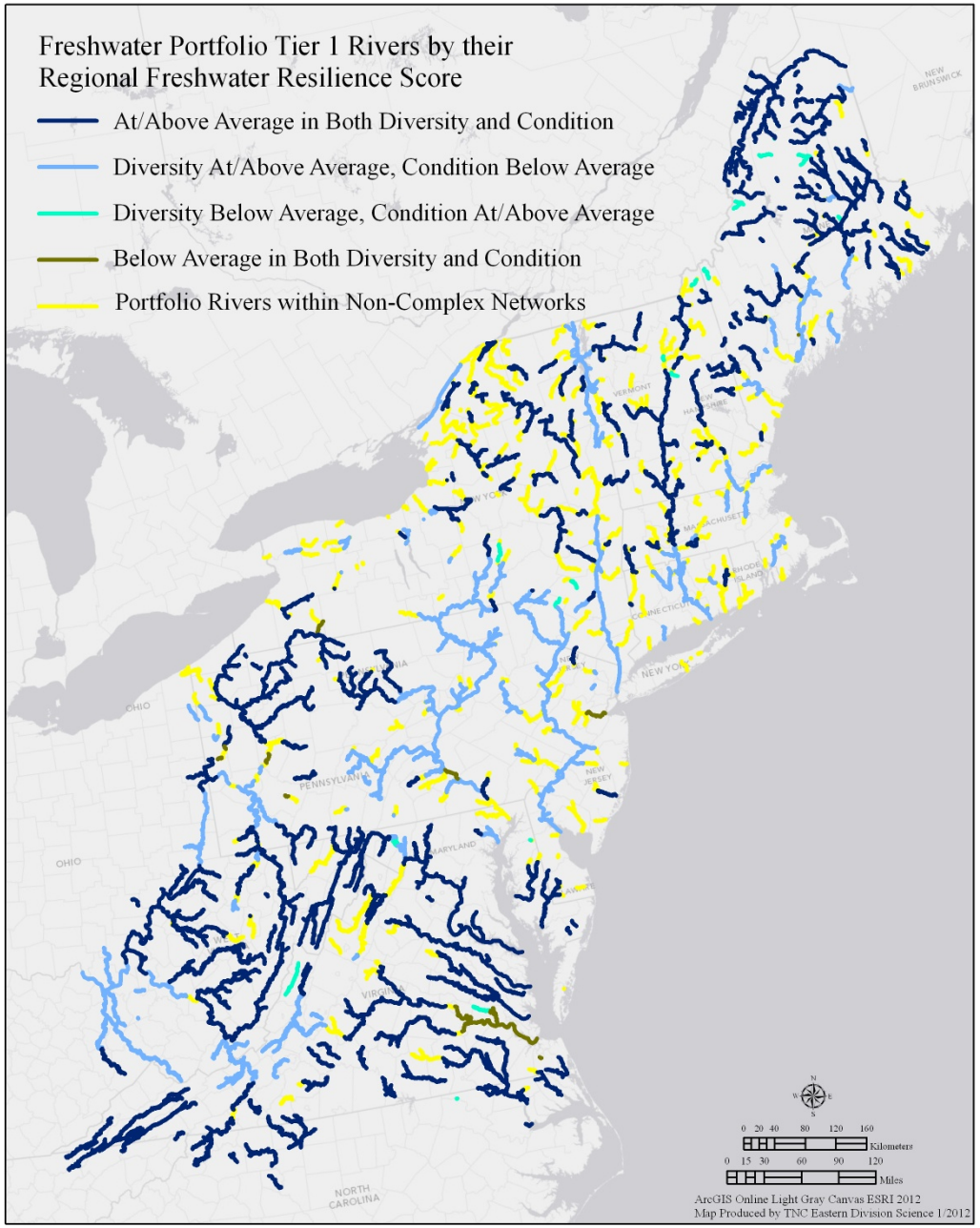
Southeast Resilience Project





Two year project, Steering committee of 29 scientists, Customizing the methodology for SE landscape. 7 states, Includes KY and TN





Portfolio Rivers by Regional Freshwater Resilience Score

Freshwater Resilience

Natural Strongholds for Aquatic Diversity

SE Dam assessment :
Colin Apse, Erik Martin

Factors
-Linear connectivity
-Diversity of gradients
-Diversity of temperatures
-Naturalness of the floodplain
-Degree of flow atleration
-Impervious surfaces in shed

"Health is the capacity of the land for self-renewal. Conservation is our effort to understand and preserve this capacity"
Aldo Leopold 1949

Thank You

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